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INFLUENCE OF THREE TEACHING MACHINE FACTORS--FEEDBACK TO PROGRAMER, PARTICIPATION BY LEARNER, AND FEEDBACK TO LEARNER ON THE PRODUCTION AND UTILIZATION OF SCIENCE FILMS.

BY- FLEMING, MALCOLM L.
INDIANA UNIV., BLOOMINGTON, DIV. OF EDUC. MEDIA

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THE PRODUCTION OF TWO EDUCATIONAL FILMS, ONE BY MEANS OF CONVENTIONAL PROCEDURES AND ONE BY MEANS OF PROGRAMING PROCEDURES CHARACTERISTIC OF SELF INSTRUCTION, AND THE TESTING OF THESE TWO FILMS IN USE-SITUATIONS WERE THE PURPOSES OF THE STUDY. FOUR HUNDRED SEVENTH-GRADE STUDENTS PARTICIPATED IN THE EXPERIMENT. THEY WERE DISTRIBUTED AMONG FIVE SCHOOLS. THE SAMPLE IN EACH SCHOOL WAS DIVIDED INTO LOW, MEDIUM AND HIGH INTELLIGENCE LEVELS. A FIVE FACTOR DESIGN WAS USED. STUDENTS WERE ASSIGNED RANDOMLY TO GROUPS AND THE GROUPS ASSIGNED RANDOMLY TO TREATMENTS. A POST-TEST AND A RETENTION TEST WERE USED. TWO GENERAL CONCLUSIONS WERE DRAWN FROM THE STUDY--(1) PROGRAMING PROCESSES FOR THE DESIGN OF A CLASSROOM FILM YIELDED A PRODUCT THAT WAS EDUCATIONALLY SUPERIOR TO THAT FROM CONVENTIONAL PROCESSES, PARTICULARLY WHEN THE FILM'S LENGTH AND RATE OF DEVELOPMENT WERE ALLOWED TO FIND THEIR OPTIMUM LEVEL BASED ON FEEDBACK FROM LEARNERS AND (2) SELF-INSTRUCTIONAL PROCESSES FOR THE USE OF EDUCATIONAL FILMS WERE SUPERIOR TO CONVENTIONAL PROCESSES, BUT IT WAS THE IMMEDIACY OF THE FEEDBACK TO LEARNERS AFTER THEIR ACTIVE PARTICIPATION THAT CONTRIBUTED MOST TO LEARNING. NO DIFFERENCE WAS OBSERVED WHETHER THE LEARNER'S PARTICIPATION WAS IMMEDIATE (DURING THE FILM) OR AFTERWARDS. (HB)

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Influence of Three Teaching Machine Factors—

FEEDBACK TO PROGRAMER, PARTICIPATION BY LEARNER, AND FEEDBACK TO LEARNER

on the

Production and Utilization of Science Films

MALCOLM L. FLEMING
Audio-Visual Center, Division of University Extension
and
Division of Educational Media, School of Education
Indiana University

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Malcolm L. Fleming

Audio-Visual Center, Division of University Extension, and
Division of Educational Media, School of Education,
Indiana University

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CHAPTER I

INTRODUCTION

It is no longer possible to make sweeping statements about educational films or to specify that "a film" is what will meet a particular classroom need. Films are as varied in their suitability for teaching as people are. Likewise varied are the processes for making and using educational films.

A frequent impetus for change in existing media design and use is the introduction of new media. Before TV, teachers were seldom filmed in the classroom, and never did the filmed person look at the cameria, i.e., at his audience. TV changed all that, though some film makers do not acknowledge that the consequent 16mm hybrids are "film."

The latest impact on media design has come from programed instruction, which has already influenced the textbook, filmstrip, film, and TV. This study is an attempt to compare experimentally the conventional and the self-instructional processes for the design and use of educational media. It was stimulated in part by B. F. Skinner's indictment of conventional audio-visual materials as compared with the new self-instructional materials. Three statements of his were questioned, and these came to form the bases for three research hypotheses (hypotheses given in Chapter III).

The first statements concerned the production of educational materials: "An unexpected advantage of machine instruction has proved to be the feedback to the programer.... A trial run of the first version of a program quickly reveals frames which need to be altered, or sequences which need to be lengthened. One or two revisions in the light of a few dozen responses work a great improvement. No comparable feedback is available to the lecturer, textbook writer, or maker of films" (17:974-75). The second dealt with learner participation during the use of educational materials: "There is a constant interchange between program and student. Unlike lectures, textbooks, and the usual audio-visual aids, the machine induces sustained activity. The student is always alert and busy" (17:971). The third dealt with feedback during the use of educational materials: "Like a good tutor, the machine insists that a given point be thoroughly understood, either frame by frame or set by set, before the student moves on. Lectures, textbooks, and their mechanized equivalents, on the other hand, proceed without making sure that the student understands and easily leave him behind" (17:971).

The issue raised in the mind of the investigator by these statements was not one of psychology versus education or teaching machine versus A-V machine, though these may seem implicit in Skinner's statements. Rather, the issue was seen as being between two educational methodologies, programed and conventional, which were conceived of as being largely independent of media or hardware and could thus be tested on the common ground provided by a single A-V medium. The choice of the educational film medium was arbitrary and largely a function of the investigator's experience with and access to conventional films. It was admitted that the experimentally programed film would not be a teaching machine program in the strict Skinnerian sense. Nevertheless, it was believed that the two educational methodologies could be more objectively compared within a single medium (film) than between two media (a Skinner machine and an A-V machine).

It was proposed that two educational films be made, one by means of conventional procedures and one by means of programing procedures characteristic of self-instruction. It was further proposed that these two films be tested in use-situations characteristic of conventional methods as well as in those of self-instructional methods.

The report of this study is divided for convenience into two parts. One deals with the programing or production phase during which the experimental materials were developed; the other deals with the use and testing phase during which the conventional and programed methodologies were formally compared in a controlled experiment.

The rest of the literature related to this study will be reviewed and the findings compared in Chapter IV, Discussion.

CHAPTER II

PROGRAMING PHASE

The choice of subject matter for the films was influenced by the following requirements:

1. Science area.

2. Appropriateness to junior high level (subject not yet studied by seventh graders in Bloomington).

3. Amenability to varied visual and verbal treatments.

The two subjects chosen to meet these criteria were the physical science topic, "Time," and the biological science topic, "Characteristics of Plants and Animals."

The initial step in programing was the determination of objectives. For the conventionally produced film, this consisted of choosing several broad objectives such as the following for the film, "Time":

1. To demonstrate both common and scientific time determination from the apparent movements of heavenly bodies.

2. To develop an understanding of the meaning and use of time zones.

3. To demonstrate the need for the International Date Line.

4. To explain the use of Daylight Saving Time.

5. To illustrate the use of time in making such measurements as rate and frequency.

These served as a general guide during the production process. At critical stages three subject-matter specialists participated and were the primary source of feedback upon which the film maker based his design and refinement of the product.

For the programed film, attention to the objectives was greatly increased. The five general objectives above were translated into fifty-five multiple-choice questions which were, in effect, operational definitions of the objectives. Though of the conventional multiple-choice type, these questions were not conceived of simply as a conventional test over the subject matter. In a sense they were the subject matter, or at least they definitively specified the aspects of the subject that were criterial. As such they defined the content that went into the first version and determined the direction taken by all revisions. Aspects of the film that did not facilitate the students' performance on the test were eliminated by the programer. About fifty students in the seventh grade participated, one at a time, and were the source of feedback on which the programer based his design and refinement of the programed film. (See section Feedback Procedure.)

Thus, two films were made--one with feedback from subject-matter experts (the conventional version) and the other with feedback from learners (the programed version). The objectives were common to both, though conceived operationally for the programed film. (See Figures 14-25 for a comparison of visuals selected from both films.)

Production and Programing Processes

Although the most fundamental difference between the two film versions was in the source of feedback for the designing and refining processes, there were other differences. These were largely inherent in the two processes being compared, that is, the conventional versus the programed. For example, the difference in specificity of objectives previously referred to, the conventional ones being very general and the programed ones being detailed and operational, is characteristic of the two processes. Other differences will be noted in the more detailed description of the two processes which follows.

The conventional process was staffed by a team of specialists who filled the roles of educational production supervisor, classroom science teacher, and university science professor. The educational production supervisor implemented the plans decided upon by the team. He possessed or had access to the necessary filmic competencies, including script writing, photography and lighting, art and animation, editing, sounding, and printing and processing. The significant steps in the process are listed below along with the frequency and timing of formal meetings with the team of specialists.

1. Planning (2 meetings)

2. Content outline (1 meeting)

3. Treatment (1 meeting)

4. Storyboard (2 meetings)

5. Scripting (1 meeting)

6. Photography, editing, sounding (1 meeting)

7. Printing and processing (1 meeting)

This conventional educational film production process had been completed before the experimental programing process began.

The programing process was staffed by a team who filled the roles of programer, tester, coordinator, artist, and photographer. (About half of this team had science backgrounds.) A science teacher and university science professor were consulted in translating the five general objectives into the fifty-five specific ones. In general, this team met more frequently--an estimated twenty-five formal meetings--usually to assess the latest feedback from learners and to plan revisions in the program.

The programed film moved through about the same steps as the conventional film except that feedback came from learners rather than from experts, the feedback was obtained much more frequently, and the revisions were more sweeping. More details on this process follow in the section Programing Procedure.

Concepts Programed

The subject, Time, as programed for this study, included the following seven topics:

1. Sundials--their use in telling time.

2. Standard time zones--how the need for them developed, how the world was divided into standard one-hour zones, and how the U.S. was divided into zones.

3. International Date Line--why it was needed, change in calendar date for travelers crossing it.

4. Daylight Saving Time--what purpose it serves, how it saves waking hours in summer but not in winter.

5. Scientific time--who determines it in the U.S., where and how the determination is made, broadcasting correct time signals.

6. Timekeeping--use of the pendulum, the lever escapement mechanism, and electricity.

7. Uses of time--in the determination of rate and frequency, in the generation of electrical current.

This, quite early, appeared to the programers to be too much material to cover adequately for seventh graders in a seventeen-minute film unit. However, in the interests of adhering to the objectives that had already been used for the conventional version, the programers attempted to make their version on the same subject matter and of the same length. This did violate the requirement that the program should be guided by feedback from learners and, hence, that the programed film should be as long as needed to achieve adequate learner performance. However, final comparison of the two versions was better controlled because of the equal instructional time for each.

The teaching-learning problem for these seven concepts included some discrete factual data such as, "National Bureau of Standards broadcasts correct standard time from radio station WWV." There were also concepts involving relationships between facts. For example, the fact that each time zone is 15 degrees wide is meaningfully related to two other facts: (1) The earth is divided into 360 degrees of longitude, and (2) One day is twenty-four hours. The relationship among these three is the following: $\frac{\text{360 degrees}}{\text{24 hours}} = \text{15 degrees in each zone}$ (see Figures 15 and 16).

Programing was also begun on the biology concepts concerning the characteristics of plants and animals. These characteristics were movement, response to stimuli, reproduction, growth, and the obtaining of energy. Programing proceeded until students could distinguish between these concepts and could properly label them. The remaining behaviors to be taught were primarily those of discriminating between certain scientific terms (cytoplasm, chloroplast, plasma membrane, etc.) and of associating them with certain pictorial stimuli (structures in living cells). These appeared to be predominantly verbal drill tasks that were more appropriate for a programed text or filmstrip than for a motion picture. Hence this program was left incomplete while energies were concentrated on the more complex concepts on the subject of time.

Programing Procedure

The basic differences between the conventional educational film production process and the experimental film programing process have been mentioned in the previous section, Production and Programing

Processes. Further elaboration of the conventional production process will not be attempted here because it is already a matter of record (3) and because it was not a direct part of this project. The color film "Time," produced conventionally and used widely in classrooms throughout the United States, was available at the beginning of this project. Thus the production of this film was not a part of the present project, although the completed film was used as the conventional version in the formal testing phase of this study (Chapter III). The description that follows is limited to the making of the programed version, which was an integral part of this project. (A comparison of some of the visuals from both versions is given in Figures 14 to 25.)

Programing as attempted in this project did not deal with frames, prompts, panels, etc., associated with most programing for texts or machines; nor did it deal initially with the usual film-making concerns for scenes, dissolves, musical bridges, etc. What was done can readily enough be communicated in either programing or film production terms, provided the writer is allowed a degree of license in their use.

The procedure used was programing in the sense that one presentation after another was made and tested on individual seventh graders, the results of which were used to revise succeeding presentations. The practical difficulty in making films this way is that the medium has none of the flexibility of a set of filing cards used in ordinary verbal programing. For example, a man with pencil, cards, and dictionary can produce words and sentences at a much faster rate than a man with camera, film, and light meter can produce scenes and sequences. As a consequence, a verbal programer can write, test, and revise on almost a daily basis, or at least weekly, while the pictorial programer will do well to film, test, and revise on a monthly basis. The effect is to reduce drastically the frequency of revisions that a film programer can make. As a consequence, the programers for this project chose to use more permissive media during all but the last three cycles of programing and testing. Many media were tried in an attempt to maximize flexibility without sacrificing too much identity with the eventual film medium. Following is a rough chronology of these exploratory media and the purpose served by each:

1. No medium except an interview schedule--subject's present knowledge of concept sought by means of both objective and open-ended questions.
2. Globe with house on it and spotlight for sun--sought ways to give subjects the basic understandings underlying the study of time (see Figure 1).

3. Two-dimensional calculator with earth as a movable disc and with meridians and dark side of earth as overlays--used to work out a sequential development of the key concepts (see Figure 2).

4. Several key line drawings with questions underneath--sought to find how subjects "read" the pictures, labels, etc.

5. Expanded series of drawings on each of the seven major concepts--sought to develop a visual sequence that would direct the subjects' attention to each relevant cue as needed and relate that cue to succeeding ones without the personalized pointing, gesturing, and verbal cuing that previously had been used.

6. Revised series of drawings used on an easel and with a tape-recorded narration--a further step toward a fixed-paced and self-sufficient medium with particular emphasis on the relationship between picture and word (see Figure 3).

7. Translation into film medium. This took several stages beginning with filmed drawings from step 6 and ending with visuals reworked to give sharper lines and some shading for three-dimensionality. Final version also included several sequences with a globe, etc., as first used in step 2.

The programed film, which had been revised according to feedback from learners, was like its self-instructional predecessors in another way. The learner was given new information a small bit at a time.

A sample section from the final film program is given in Figures 5-13.

Feedback Procedure

The method of eliciting responses from seventh grade subjects was also highly flexible and exploratory. Typically, the students were tested in the schools, using a conference room, music room, storeroom, or small classroom. Each encounter was generally with one student and lasted a school period. Students tested were chosen by the principal or counselor to represent a range of abilities. It became apparent early that I.Q. would interact importantly with criterial behavior. This forced a judgment as to which level of learner would be given most attention. Though feedback from students of a range of abilities was generally obtained, the average student was favored. (In the formal testing phase, Chapter III, I. Q. was used as a classification factor to divide treatment groups into ability levels.)

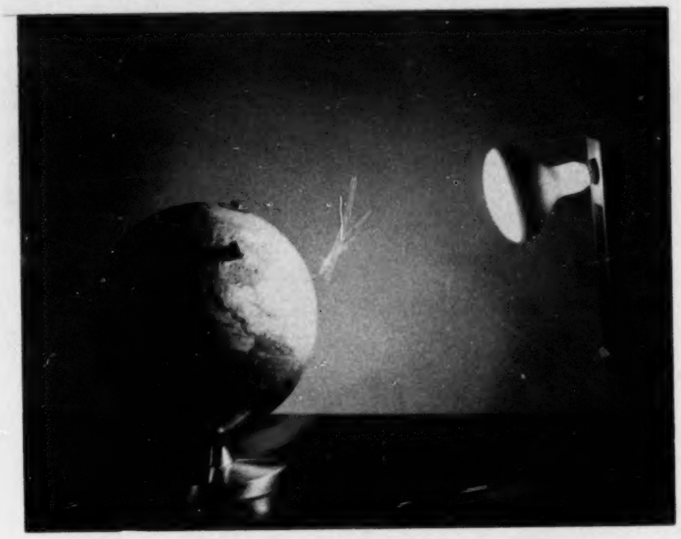


Figure 1. Globe and "sun" used to teach and test basic concepts regarding time.

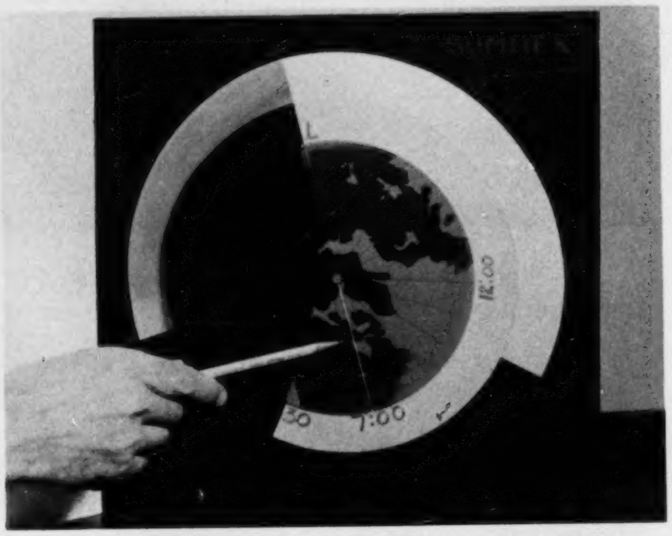


Figure 2. Calculator permitting teaching and testing of facts and understandings about Standard Time, Daylight Saving Time, and International Date Line.

The first problem was always to set the subject at ease. This was done by emphasizing that it was the teaching material that was being tested rather than the student. Then the program was presented bit by bit, with feedback of some sort elicited between bits.

The frequency, quantity, and character of feedback sought and obtained were different each time. In part this was a function of the material being tested, and in part it was the product of continuing effort after improving the technique. If a value judgment were to be made at this time, it would favor the following procedure: (1) Have the subject read the item out loud (this shows up words and verbal structures likely to be misunderstood); (2) Have the subject read each alternative aloud and make a choice (no indication from experimenter as to the correctness of each choice); (3) Have the subject tell why he chose or did not choose each alternative (see Figure 4).

This procedure yields much diagnostic information concerning the flaws of the program and of the item; however, it gives the subject a severe grilling and must usually be accompanied by generous encouragement and praise by the experimenter.

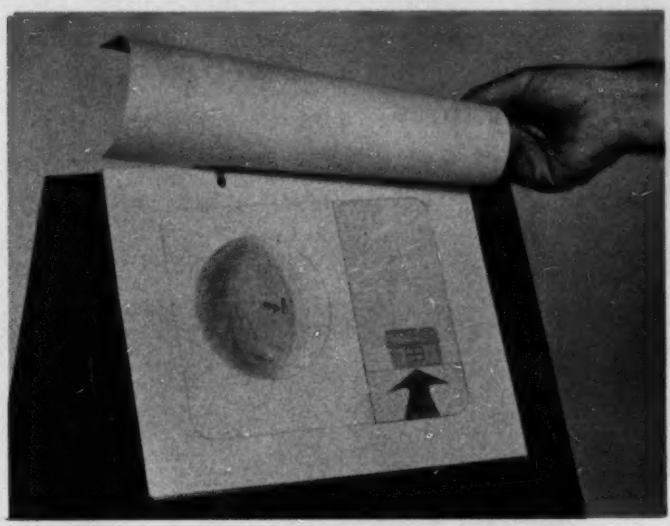


Figure 3. Flip chart or storyboard used in programing of unit on time.

Figure 4. Typical encounter between programer and seventh grader.

In addition, much other pertinent data were obtained. What did the students already know about longitude, degrees, earth rotation, changing to Daylight Saving Time, etc.? How would they explain to a friend what they had just learned about how the earth is divided into zones? What was it in the words or pictures that made them choose the answers they did? Were the words and pictures coming at them too fast? Could they understand the words the man said? (The responses of each subject were generally tape-recorded for subsequent study.)

Criteria for Some of the Programing Decisions

1. Fact versus Principle. Testing of the earliest version indicated an inferior performance on items dealing with principles as compared to those dealing with facts. Subsequent versions gave more stress to basic principles. The intent here was not only to teach the generalization but also to provide the student with a basis for reasoning out other relationships instead of depending on rote memory. For example, the basic concept of the earth's rotating to the east into the sun's light can be used to show why we say that the sun "rises" in the east. It also clarifies why the Eastern Zone of the United States rotates into the sunlight first and hence is an hour ahead of the Central Zone.

2. Relative Emphasis on Each Concept. Testing of the earliest version showed that the weakest sections were those dealing with Daylight Saving Time and the International Date Line. Consequently, these were expanded in length, while others judged to be less relevant and less criterial were reduced. In addition, the opening titles were shortened and the general introduction eliminated.

3. Pictorial Concreteness versus Abstraction. The conventional version included about equal amounts of live photography and animation art. The programed version consisted essentially of art and a few models. This was the result of the simplified initial visuals (just outline drawings), which were made more representational only if and when feedback seemed to warrant it. The result was that they stayed relatively abstract and, as art, relatively unfinished in the commercial sense (see Figures 5-7, for example).

4. Color versus Black and White. The conventional version was in color, while the programed version was in black and white. Early phases of programing used black and white drawings. The addition of color as an emphatic device was considered and given a very limited tryout. No learner expressed a need for color, though learners might well have profited from it. Time did not permit an adequate test of this factor.

5. Personal versus Impersonal. The final narration was impersonal for both versions, but probably somewhat more so for the conventional. Pictorially, the programed version was less personal in that it showed fewer people. However, stick figures, houses, etc. were added to some map and globe scenes after conversations with seventh graders revealed a large element of personal reference with regard to time problems. "The sun sets in the west because I can see it out of my bedroom window, which is on the west side of my house." "Eastern Standard Time is ahead of Central Standard Time because Grandmother lives in New York City and her clock is ahead of ours."

6. Word Density. A film study by Jaspen (11) found the optimum word density to be about one hundred words per minute for teaching a psychomotor skill. However, the film producer's usual tendency is to keep words in the narration to a minimum density to allow the audience more energy and time to "read" the picture and to avoid making words dominant over the picture. Programing experience on this film forced a qualification of the above view to take cognizance of a novelty-redundancy dimension in addition to the one of greater or lesser word density. The resulting hypothesis was that a sharp increase in word density would be permissible (and possibly desirable) as long as there was a concurrent increase in redundancy. The final programed-film narration tended in this direction instead of following the conventional tendency to reduce word density, to avoid word repetition, and to make each word count by making it give new information. The rule that too many words compete with the visual would seem instead to apply differentially, according to the total quantity of new information presented by the words. Support for this view comes from Hoban (9:107).

> The relationship between redundancy and learning has been shared in human insight and acceptance for centuries . . . .
>
> Ironically, the communications engineer and the information theorist take a dim view of redundancy, and try to minimize it in order to increase transmission efficiency. Similarly, the English teacher in high school and college frowns on redundancy, identified as tautology, and expends considerable effort to teach students to avoid it in formal writing assignments. All in all, the use of redundancy in communication is an uphill fight.

It was also theorized that insofar as the narration guided and directed the attention of the learner, it should be essentially continuous though as free as possible of monotony and complexity.

A sample of the narration from both films follows:

Conventional	Programed
For centuries man has used the sun as a timekeeper. 12 o'clock noon means that the sun is at its highest point in the sky, that an object casts its shortest shadow, that in the northern hemisphere the shadow points due north. From these observations man invented the sundial.	The earth, spinning around in the sun's light, again and again, like the hand of a clock, sweeping around and around. For centuries man found this rotation of the earth to be steadier, more regular, more reliable than anything he himself could make.
But sundials work only when the sun shines, and they tell only local time. Sundials farther east or west tell different times.	One early time-keeping device that made use of the earth's rotation to determine the time of day was a sundial. The sundial marks time by casting a shadow which changes length and direction as the earth rotates through the sun's light. Because these sundials are at different points in the sunlight, their shadows are different; and, therefore, we say they tell different times. Sundials measure only changes in shadows; they do not measure either the heat of the sun or the brightness of the sun.

While students at one location on the earth are in school, students at another location will just be leaving for school, while at still another location students will still be sleeping. Since each of these students is at a different position in relation to the sun, each will have a different sun time or local time.

(Figure 14 was one of the visuals accompanying this narration.)

7. Similarity and Proximity (Temporal and Spatial). The perceptual principles of proximity and similarity proved useful. For example, in the DST sequence two houses were drawn so as to be quite similar in all respects except the criterial one--time, one being on Standard Time and the other on Daylight Saving Time. This resulted in inviting the viewer to compare the houses only in the desired dimension--time. The added clocks and labels had to be placed so that they bore an evident spatial proximity to the right house (see Figure 18).

The Daylight Saving sequence brought into temporal proximity the answers to two important problems--why change to Daylight Saving Time and how to make the change. These are normally widely separated in time. We set our clocks ahead the night before, but the pay-off comes the next morning. The program, by bringing these two together temporally, could inductively develop them both in a more direct manner, essentially as follows:

> It is 6 a.m. on a summer morning. This part of the earth has been rotating into the sun's light for about two hours, but the people in both houses are still sleeping. One of them would like to get up and go to work, but he doesn't usually get up until his clock says 7. So one morning he just turned his clock ahead one hour, from 6 to 7, and got up. He is now on Daylight Saving Time, while his neighbor is on Standard Time and is still asleep.

(Figure 18, right, was one of the visuals accompanying this narration.)

8. Motion versus Nonmotion. The completed programed film contained a minimum of motion, in part due to the fact that through most of its development it was in a still medium. Many cues pop on and off the pictures, but few actually move across. Because the motion of the earth was judged to be such an important basic concept, the earth was

shown in motion wherever possible. In fact, the dominant movement in the whole film is that of the earth.

9. Rate of Development. The best version in still picture form was the longest (25 minutes). The best film version was again the longest (22 minutes). (In both cases "best" is a judgment based on a sample of about five subjects tested in the informal manner employed during programing.) No shorter versions appeared to equal these. The difference was primarily one of rate of development, the slower rate being the better.

To permit a formal test of the factor of development rate, a "long" film version (21 minutes) was made that was the same in all ways as the final programed version (17 minutes), except that some scenes were longer and that the narration was read more slowly and with more pauses. The long version was tried with seventh graders in one school (see the section Utilization and Testing later in this report).

10. Order of Presentation. Major concepts in the programed version were presented in essentially the same order as in the conventional version. The only change in order that was suggested by feedback from learners was to reverse the order of two sequences. This would have made the order go: Standard Time, Daylight Saving Time, and International Date Line rather than Standard Time, International Date Line, and then Daylight Saving Time. This change was considered as a remedy for some interference that for certain students seemed to develop among the three concepts. The final decision was to leave the order intact but to follow the three sequences with a review that attempted to repeat difficult parts and relate the three concepts so as to eliminate possible interfering tendencies.

11. Visualization. Much exploration was done to discover pictorial symbols that revealed the most relevant aspects of the subject. This involved two steps that were sometimes indistinguishable: determining what aspects defined the subject matter and designing visuals to characterize those aspects. The best solutions to this search for the elusive relevant cues came from brainstorming sessions where both programers and graphic and photographic artists participated.

A few generalizations about visualization follow. They are based on empirical evidence gleaned during programing and are not supported by controlled experimentation.

a. A quite complex visual field can be "read clearly" by seventh graders if the initial field is simple and the other elements are added and identified a few at a time. This way novelty or change in the field is small at any moment and limited to the criterial aspect where the learners' attention must be focused (see Figures 5-13).

b. Movement can be readily perceived by seventh graders from a series of three successive still pictures having the "moving" object in a different position for each. However, a single still picture showing all three positions may be misread even if there are connecting arrows.

c. In general, seventh graders do not show facility in handling questions posed by pictured situations. However, they did not object to them as unfair or unworthy modes of testing as did several university students (see Appendix for pictorial test items).

d. The lack of some of the niceties of conventional film continuity, etc. is not objected to by seventh graders. For example, several bad "jump cuts" were not noticed.

e. Transitions from pictured objects to their verbal referents may need to be gradual for seventh graders. Particularly, there should be an intermediate step showing both pictured object and word before the word is dealt with alone (see Figures 8-10).

f. Change in perspective or viewpoint should be purposeful and, if quite extreme, should be well anticipated and explained. For example, the concept that sunrise really is attributable to the motion of the earth rather than to that of the sun cannot be convincingly demonstrated from the viewpoint usual to us as we ride on the moving earth. Hence, an off-the-earth view was necessary "to see" the earth do the moving (see Figure 14). When it became necessary to see twenty-four one-hour time zones at once, a polar view of the earth from above the North Pole was chosen; but the narration alerted the audience to the change, and the North Pole was labeled on the picture (see Figure 17, right). (North Pole label came earlier in the sequence.) Still later, in dealing with Daylight Saving Time, the viewpoint was that of the earth and sun as we normally see them. This seemed the most suitable way to consider the down-to-earth problems of whether to sleep or work during the early morning hours in summer and how to set the clock accordingly (see Figure 18, right).

SAMPLE SECTION FROM PROGRAMED FILM

Pictures **Narration**

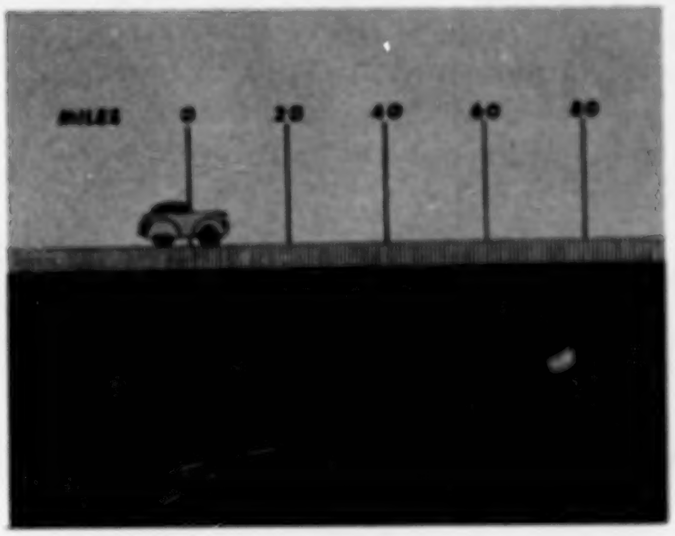

MILES
0
20
40
60
80

Figure 5.

Being able to keep time helps us talk about the rate of speed at which an object is moving or the frequency with which something happens.

For example, at what rate will this car be moving?

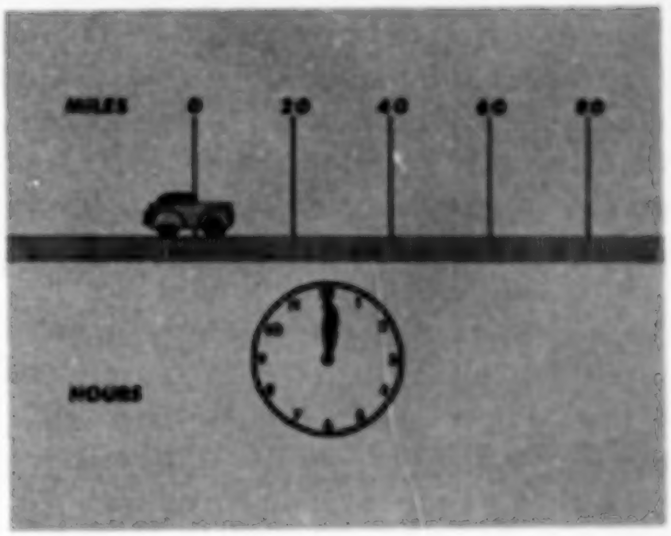

MILES
0
20
40
60
80
HOURS

Figure 6.

It begins its journey at 12 o'clock.

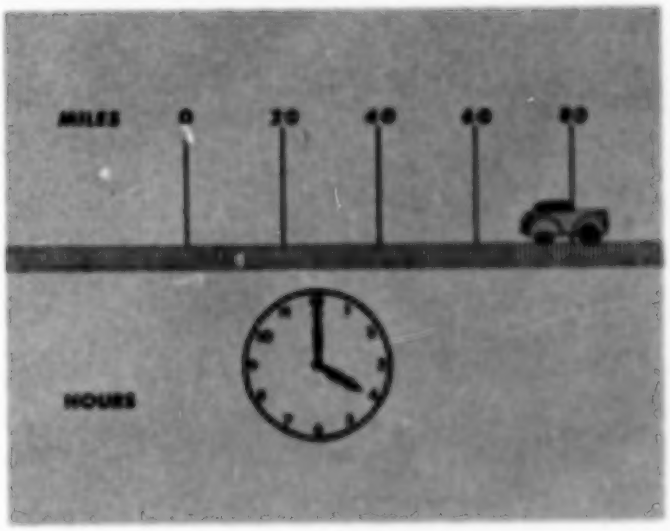
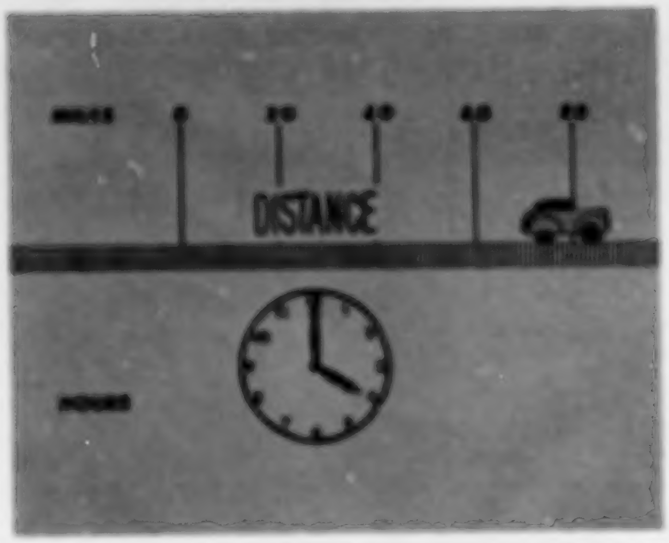
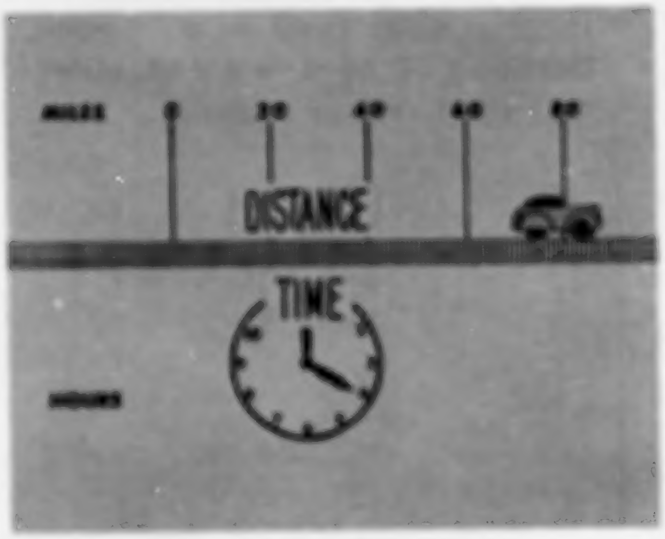
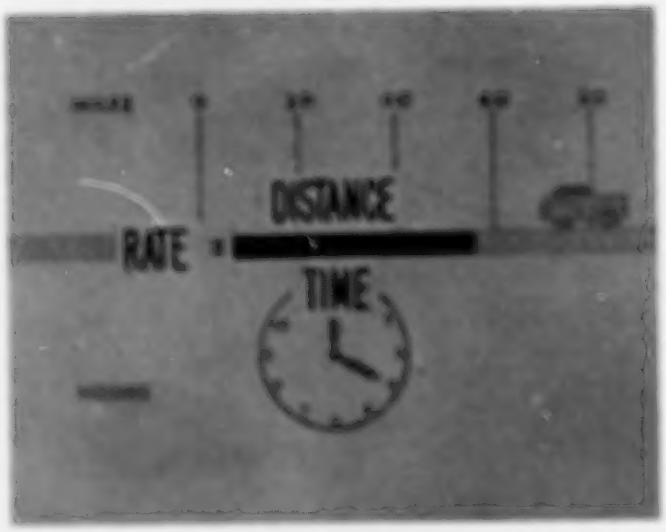
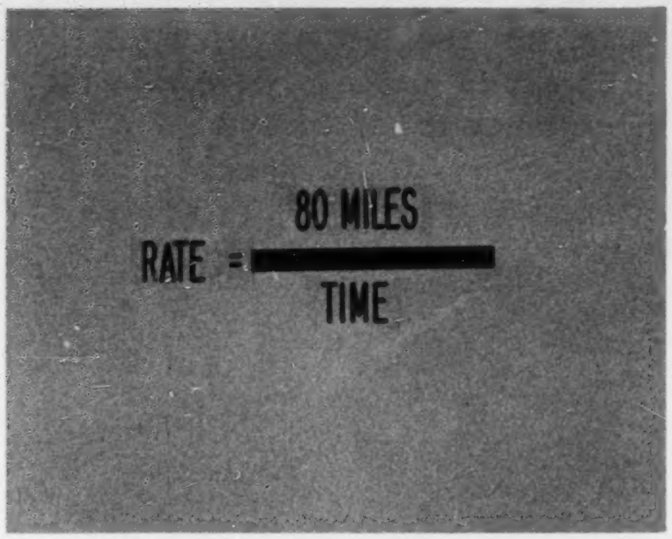
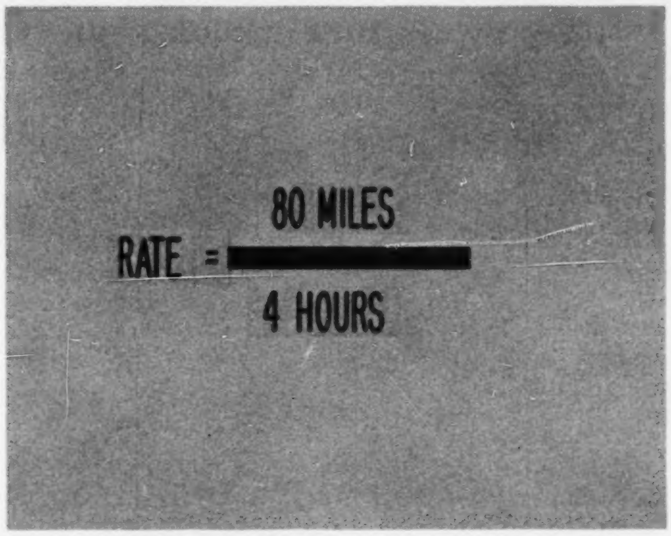
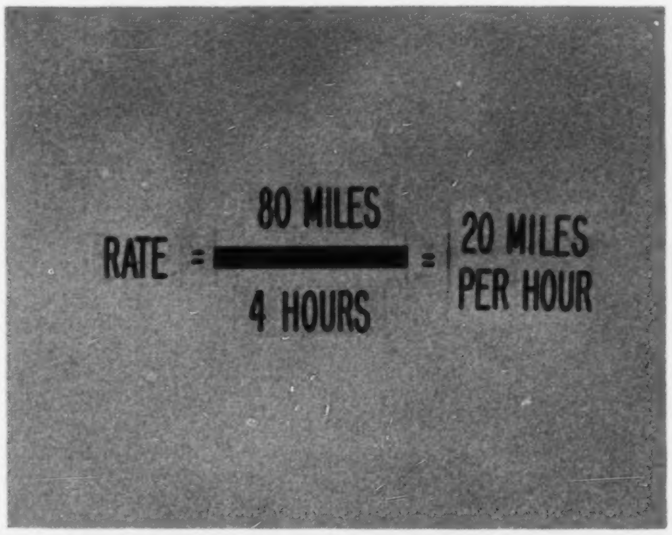

MILES
0
20
40
60
80
HOURS

Figure 7.

By 4 o'clock it has traveled a distance of 80 miles. The time it took to travel that distance was 4 hours.

Pictures	**Narration**
 Figure 8.	**To find the rate at which an object is moving, we divide the distance it has moved . . .**
 DISTANCE TIME Figure 9.	**. . . by the time it took to move that distance.**
 DISTANCE RATE = TIME Figure 10.	

Pictures	Narration
 RATE = 80 MILES TIME Figure 11.	In our example the distance was 80 miles . . .
 RATE = 80 MILES 4 HOURS Figure 12.	. . . and the time was 4 hours. Dividing 80 by 4, we conclude that the car was moving . . .
 RATE = 80 MILES 4 HOURS = 20 MILES PER HOUR Figure 13.	. . . at the rate of 20 miles per hour.

SAMPLE VISUALS FROM CONVENTIONAL AND PROGRAMED VERSIONS

Conventional Version   Programed Version

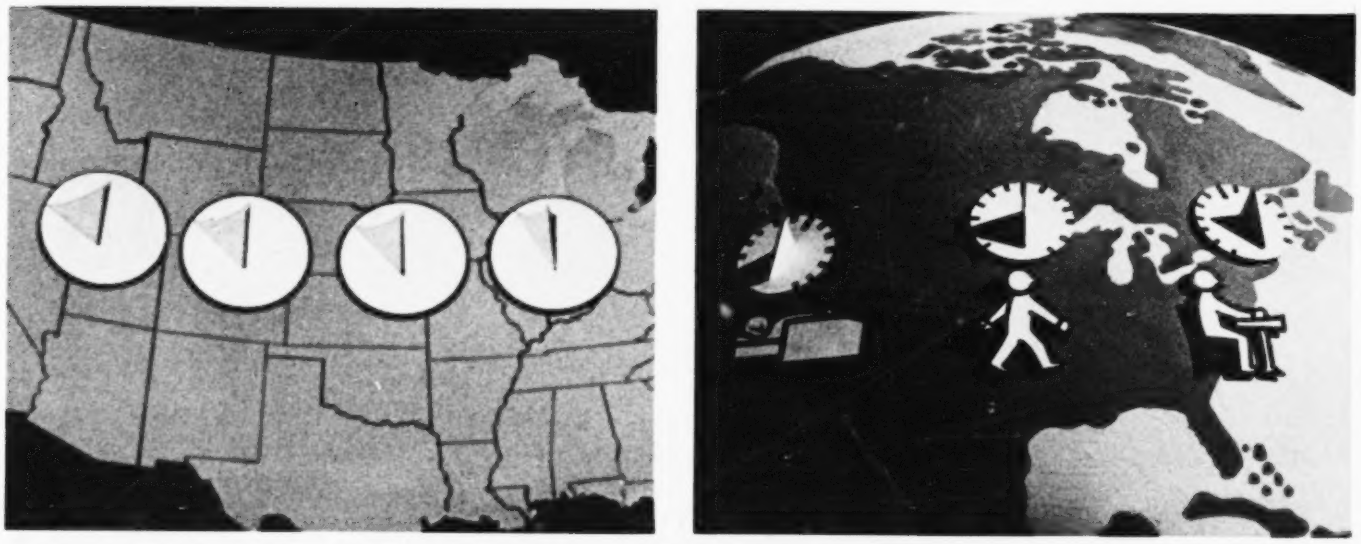


Figure 14. Local time or sun time was different in each part of the country.

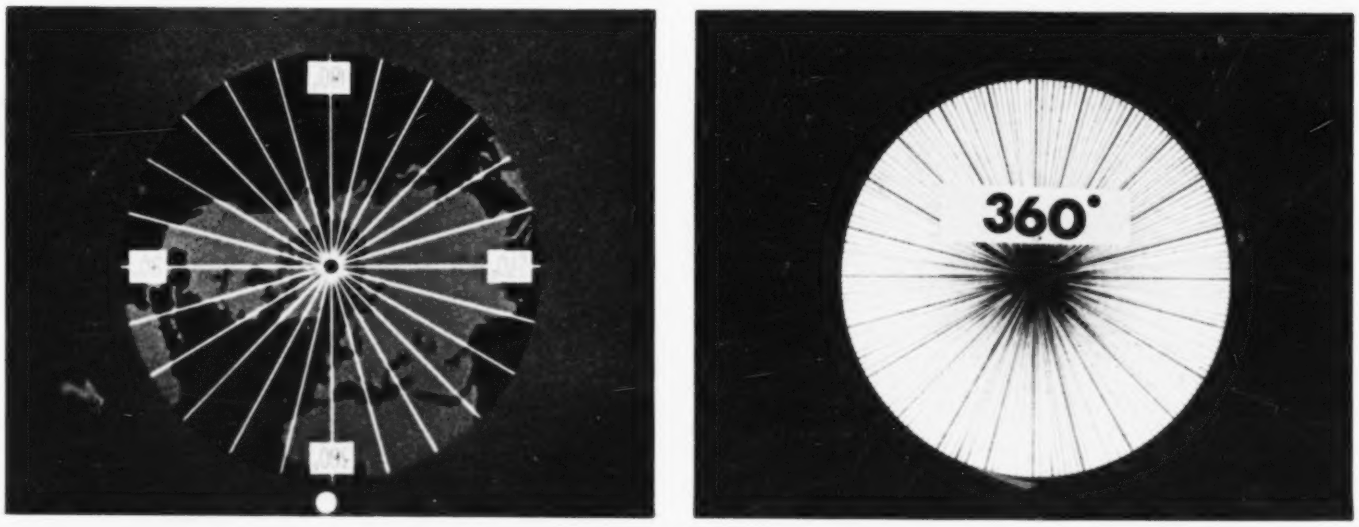


Figure 15. The earth rotates through 360° . . .

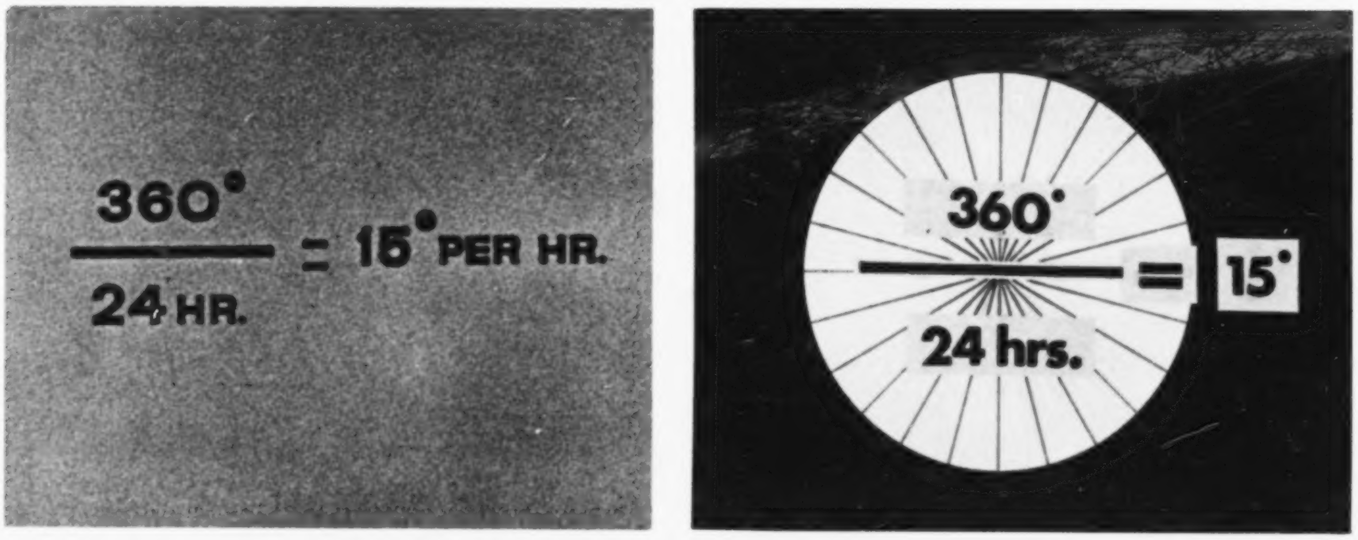

360°
24 HR.
= 15° PER HR.
360°
24 hrs.
= 15°

Figure 16. . . . in 24 hours. Hence each time zone is 15° wide.

Conventional Version **Programed Version**

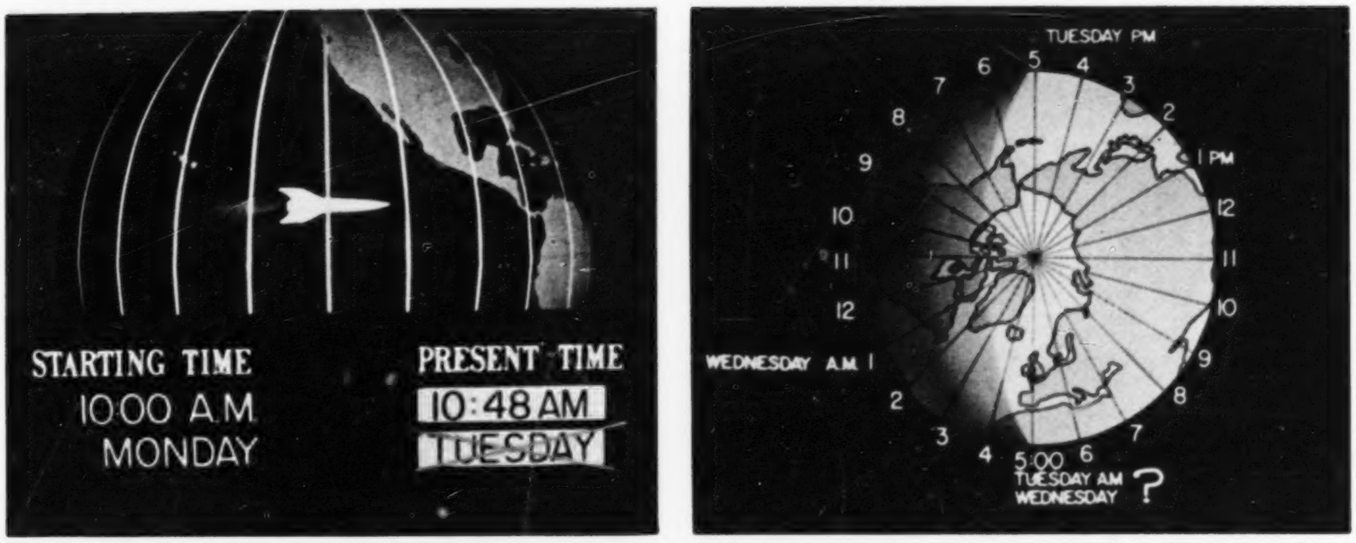

STARTING TIME
10:00 A.M.
MONDAY
PRESENT TIME
10:48 AM
TUESDAY
TUESDAY PM
1 PM
WEDNESDAY A.M. 1
5:00
TUESDAY AM
WEDNESDAY ?

Figure 17. Trip around earth, changing only the clock, results in one-day error. Hence the need for International Date Line for changing the calendar day.

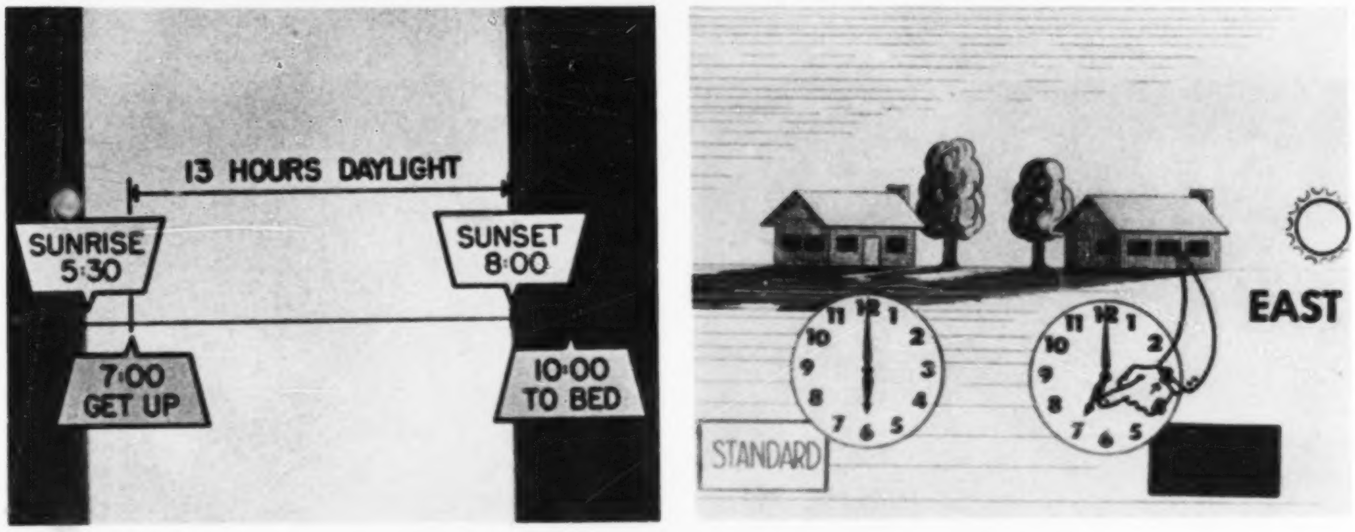

13 HOURS DAYLIGHT
SUNRISE 5:30
SUNSET 8:00
7:00 GET UP
10:00 TO BED
EAST
STANDARD

Figure 18. Change to DST in summer saves "waking" hours of daylight.

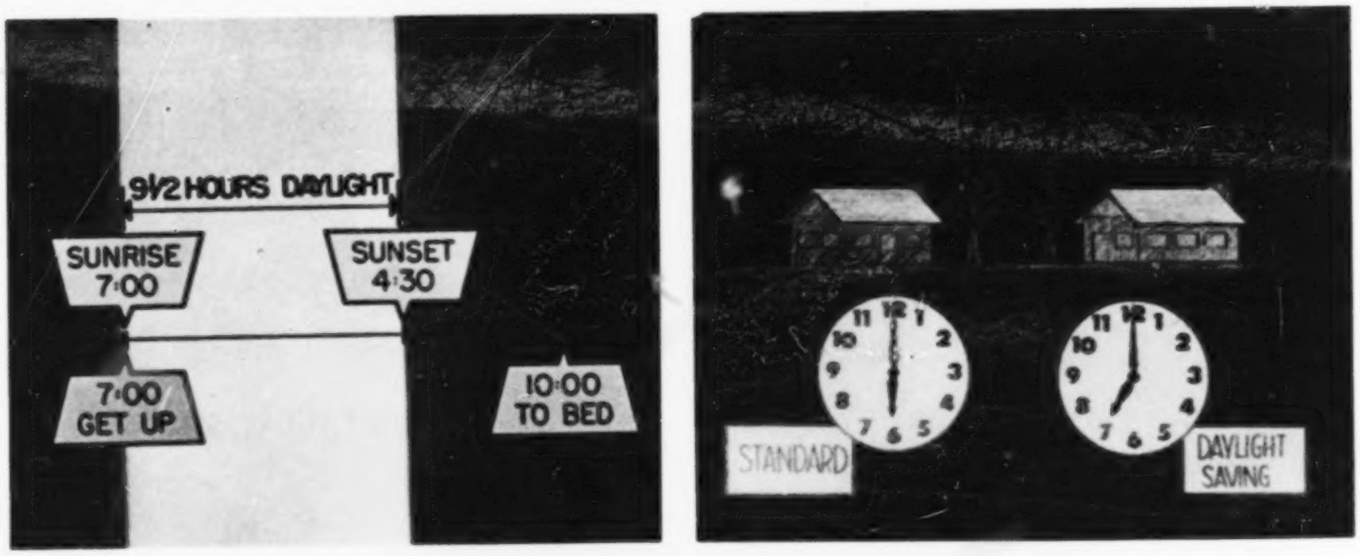

9 1/2 HOURS DAYLIGHT
SUNRISE 7:00
SUNSET 4:30
7:00 GET UP
10:00 TO BED
STANDARD
DAYLIGHT SAVING

Figure 19. DST in winter gives no gain in "waking" hours of daylight.

Conventional Version Programed Version

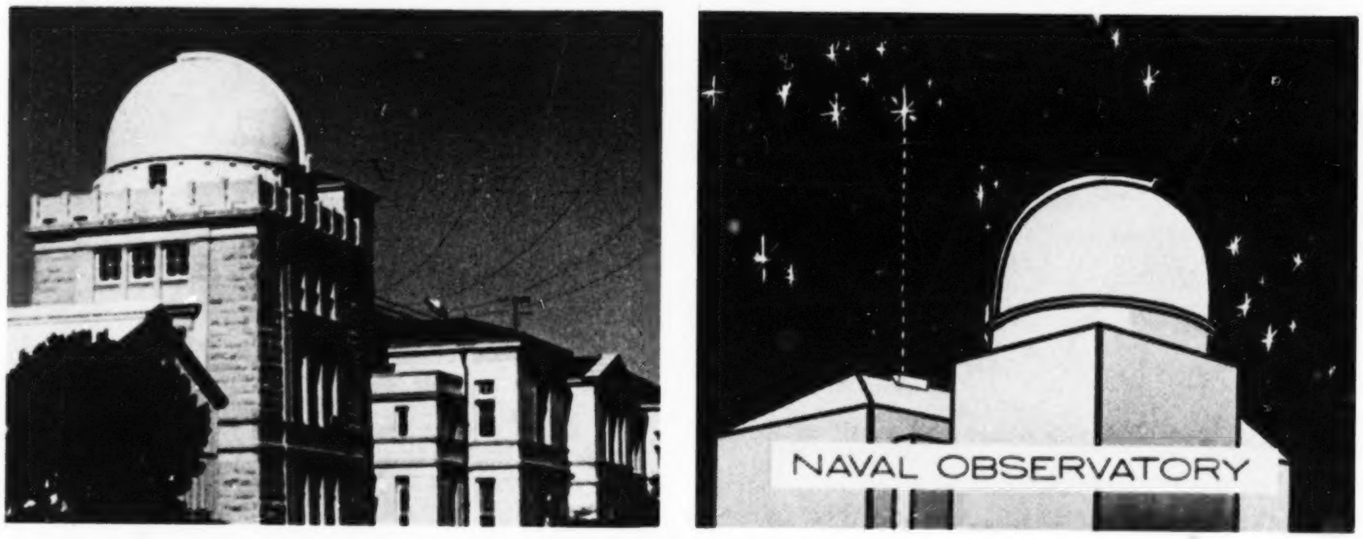

NAVAL OBSERVATORY

Figure 20. Scientific time determined at Naval Observatory . . .

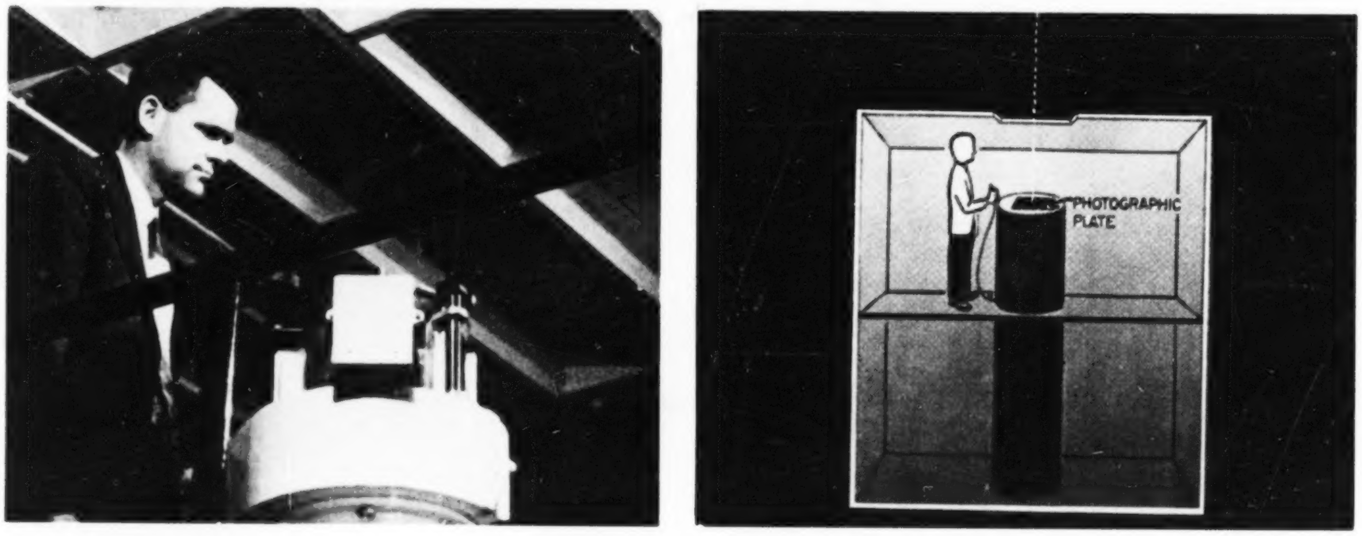

PHOTOGRAPHIC
PLATE

Figure 21. . . . from pictures of the paths of stars passing overhead.

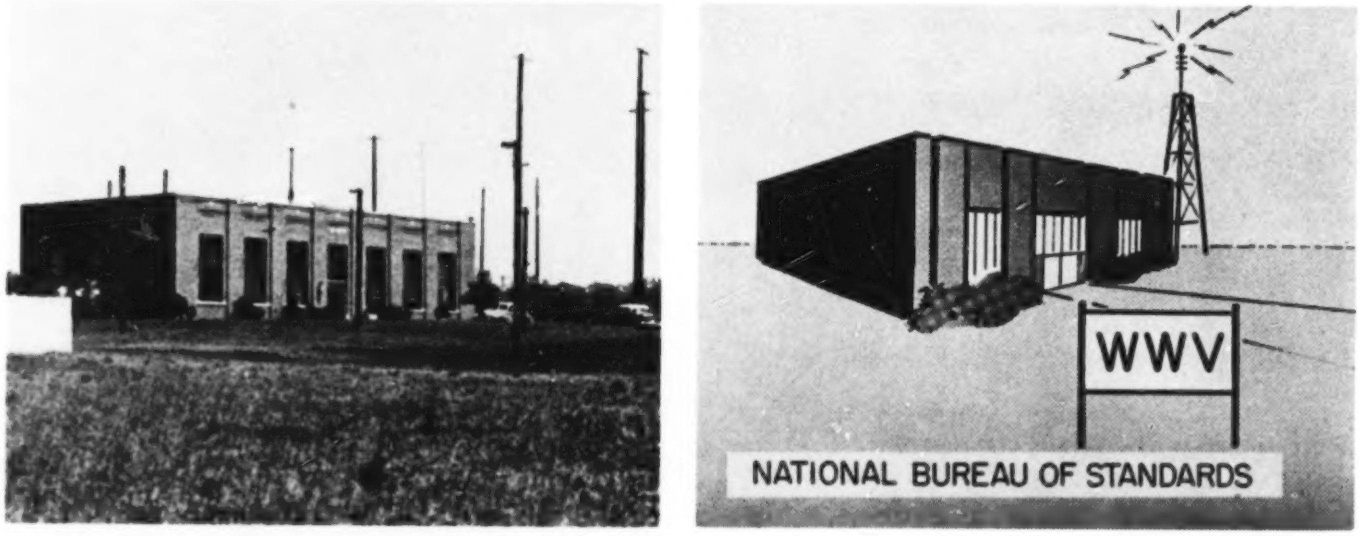

WWV
NATIONAL BUREAU OF STANDARDS

Figure 22. Correct time signals broadcast from station WWV.

Conventional Version Programed Version

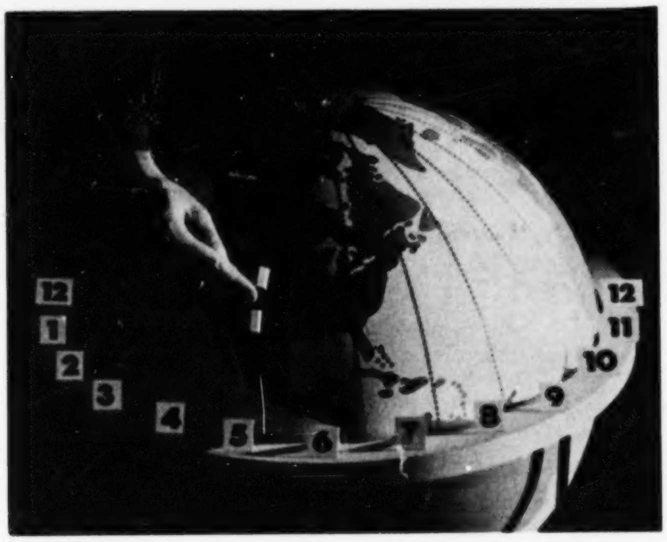

12
1
2
3
4
5
6
7
8
9
10
11
12

Figure 23. Review of relation of time determination to motion of the earth.

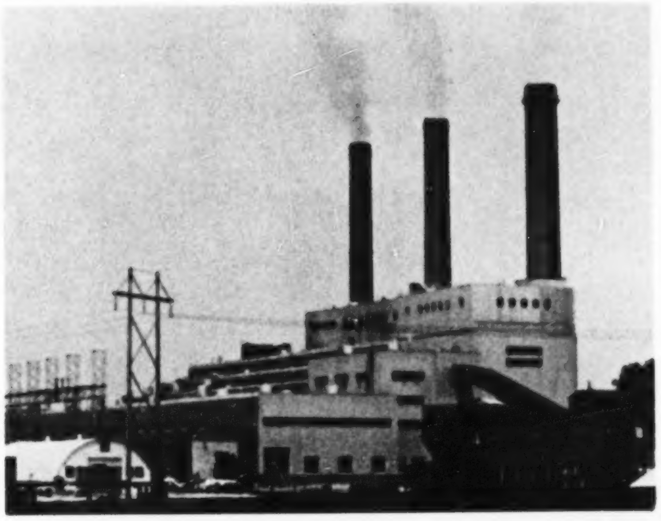


Figure 24. Time is important in the generation of electrical current . . .

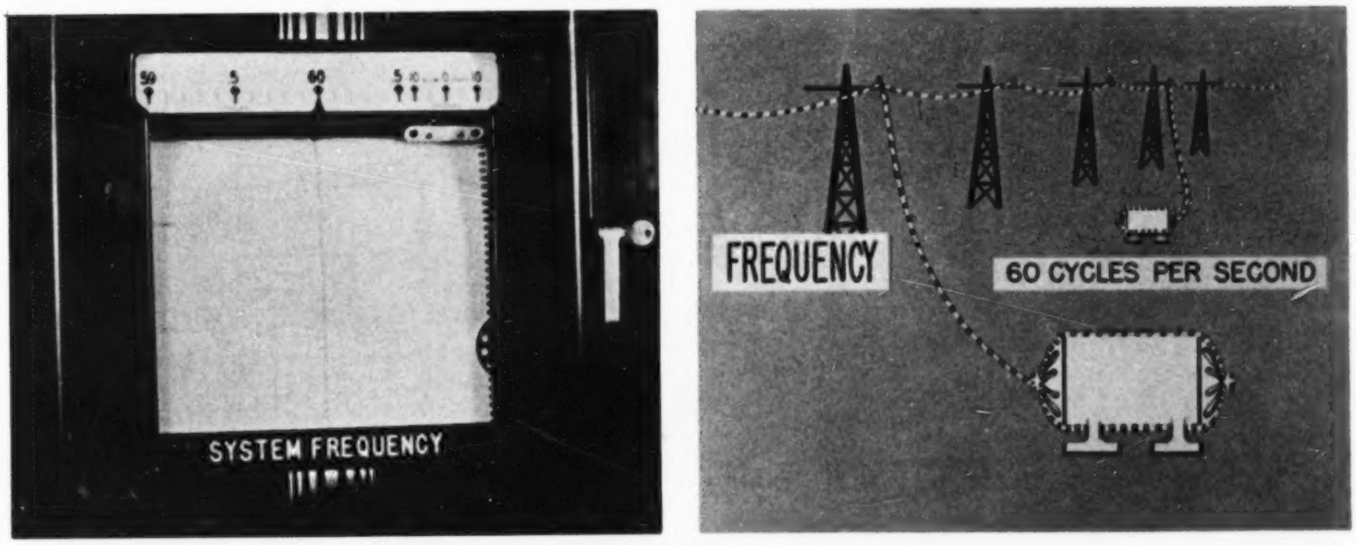

SYSTEM FREQUENCY
59
5
60
FREQUENCY
60 CYCLES PER SECOND

Figure 25. . . . whose frequency must be 60 cycles per second.

Summary

The programing phase attempted to create a film through application of certain programing principles. The film dealt with the same subject for the same amount of time as did a previously made film produced by conventional processes. The programed film was also directed toward the same objectives and the same audience as the conventional film.

If any generality were to be expressed concerning staff experience in the programing phase, it would be the self-evident observation that decision making throughout was on a tenuous basis--something better than blind trial and error, but far from any reliable basis of theory and principle. Over and over the question was raised, "What are the most relevant cues for the perception and learning of this concept?" Finding no sufficient answers, we sought in this report at least to make public some of the bases, however inadequate, for our programing decisions. If this practice could become more prevalent among programers, and if further controlled experimentation could follow up the hunches from teachers and programers, a more nearly scientific process of educational problem solving should evolve.

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CHAPTER III

UTILIZATION AND TESTING PHASE

Design

Two films, one made by conventional processes and the other by programing processes, were formally tested in four utilization situations that differed along the same dimension; that is, two were to typify conventional utilization and two, programed instruction.

The conventional utilization situation was characterized by delayed participation and delayed feedback. In effect, this meant that students did not answer questions about the film until after it had been shown in its entirety (delayed participation). Also there was no knowledge of test results until the next day (delayed feedback).

On the other hand, the programed instruction situation was characterized by immediate participation and immediate feedback. This meant that students answered questions after each of the seven major sequences (immediate participation). They also obtained the correct answers after answering each question (immediate feedback).

In sum, the formal testing constituted a 2 x 2 x 2 factorial design, giving eight treatment groups as shown in Table 1. A more complete description of the production variables was given in Chapter II, and more information concerning the utilization variables follows in the section on testing procedure.

Table 1. Basic Design of the Study.

	Utilization Variables			
Production Variables:	Delayed Feedback (conventional)		Immediate Feedback (programed)	
	Participation		Participation	
Source of feedback to programer or producer	Delayed (conventional)	Immediate (programed)	Delayed (conventional)	Immediate (programed)
Expert (conventional)	1 (DF-DP)	2 (DF-IP)	3 (IF-DP)	4 (IF-IP)
Learner (programed)	5 (DF-DP)	6 (DF-IP)	7 (IF-DP)	8 (IF-IP)

Experimental Population and Sampling

An initial population of more than four hundred seventh graders participated in the experiment. These were distributed among five schools in the Bloomington Metropolitan School System. One school having one seventh grade was used in establishing the reliability of the test instruments. In each of the other four schools the basic design (Table 1) was replicated.

The subpopulation in each school was further divided into low, average, and high ability (I. Q.) levels. Treatments were applied to all three ability levels together, but for the analysis each treatment group was divided into three I. Q. levels: 64 to 101, 102 to 111, and 112 to 147. These particular levels were chosen because they permitted division of the population into three equal parts and thus facilitated the assigning of equal numbers of subjects to each cell in each replication. * The need for such a division to better control type S errors (15:9) was apparent early in the programing phase as noted in Chapter II.

This, in effect, yielded a 5-factor design: treatments (2 x 2 x 2) by I. Q. levels (low, average, high) by replicates (four schools), i. e., it was a 2^3 x 3 x 4 design, or what Lindquist might call an A x B x C x L x R design (15).

Students in each school were assigned randomly to groups (the eight treatment groups) and the groups assigned randomly to treatments. The procedure was to form groups by dividing an alphabetical list of all seventh graders in a school into eight parts. Each such group was assigned to a treatment by use of a table of random numbers.

Test Construction

Two test forms were used in the testing phase of this study. One, the post-test, was the occasion for the students' "participation" during the learning phase for all conditions. It was taken by the learner after seeing the film, immediately or delayed, and feedback of correct responses to it was given immediately or delayed. The post-test contained forty items and was essentially the same test as that used and refined during the earlier programing phase except that fifteen questions were eliminated--those most often answered correctly regardless of the film version encountered by the subject. It was comprised of

---

*In order to achieve this proportionality throughout, the exact parameters of the three levels were shifted slightly for 11 of the 96 cells, but no shift was greater than the standard error of the mean, i. e., the published 4. 0 points for the Otis Quick-Scoring Mental Ability Test-Beta Form.

four-alternative multiple-choice items. Approximately one third of the items incorporated pictures either as part of the information in the lead or as the four alternatives (see test in Appendix).

The retention test was like the post-test. Although it posed the same kinds of questions about the same content, the phrasing was changed, some new alternatives were substituted, and different data were inserted in problem items. The order of items was random, whereas in the post-test the items were in the same order as the corresponding concepts in the film (see test in Appendix).

Test reliability computations were made for the two test forms, using thirty-nine eighth grade subjects and testing on successive days. For the post-test an average of 72 per cent of the items was answered correctly, and for the retention test an average of 70 per cent was answered correctly. Standard deviations were 4.74 and 4.85, respectively. As an index of reliability, the coefficient of correlation between the two tests was computed and found to be .75 (6).

The tests were mimeographed and bound into booklet form. There was one item a page except where one picture was the basis for several questions. In this case the picture and related questions were on one page.

In half the test booklets feedback was also provided. Each question page was followed by an answer page folded to cover the answer and make it less accessible to those tempted to "peek." The student would study a given question, mark his response on a separate IBM sheet (see Figure 26), turn the question page over (see Figure 27), unfold the answer page (see Figure 28) to reveal a restatement of the question plus the correct answer (see Figure 29), and then turn over the answer page to reveal the next question.

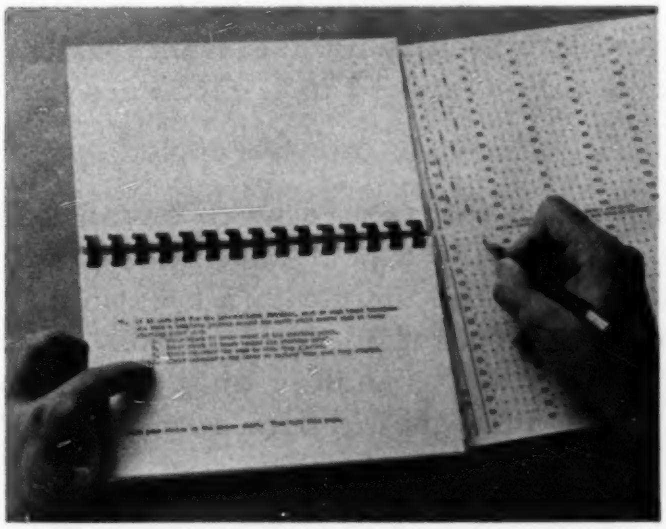

Figure 26.

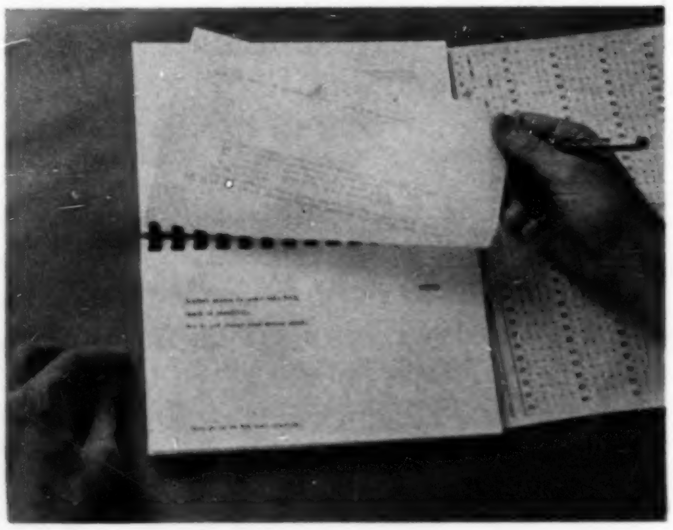

Figure 27.

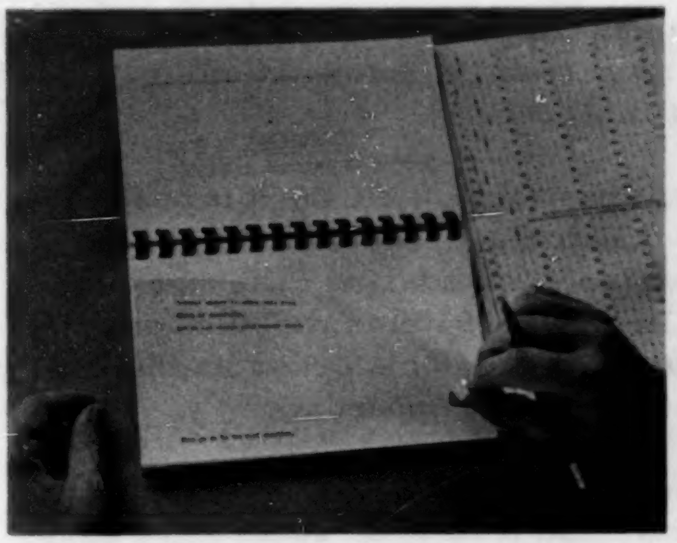

Figure 28.

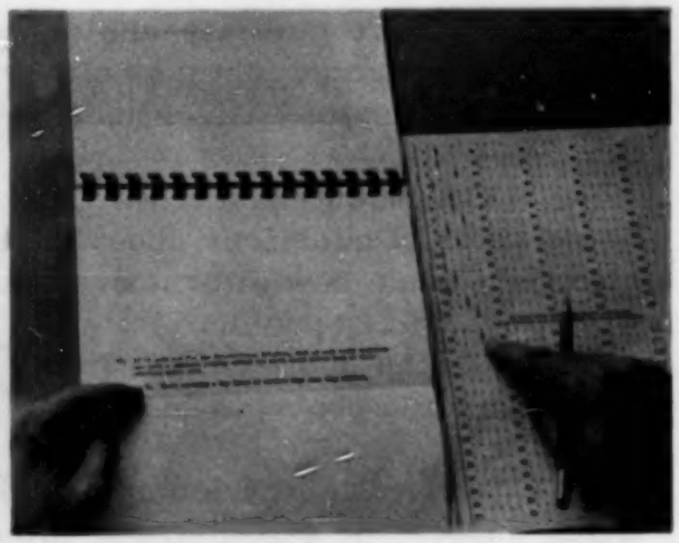

Figure 29.

Testing Procedure

Each school was visited three times, as follows: (1) Orientation was given, film was shown, post-test (participation) was administered, and feedback was given to those who were to receive it immediately. (2) Next day, feedback was given to those who were to receive it delayed. (3) Two weeks later, retention test was given to all.

Phase 1 for any particular school was administered to all eight experimental groups simultaneously. Phase 2 was administered to all groups simultaneously in schools 1, 3, and 4 and was given successively to one group after another during one day in school 2. Phase 3 was given to all groups simultaneously in schools 1 and 4 and was given successively during one day to group after group in schools 2 and 3.

Actually, the randomly comprised experimental groups were intact only for phase 1, when the different treatments were administered. For the succeeding phases students were in their normal class groupings. All phases were administered by university faculty or assistants with teaching experience. These were randomly assigned to treatments for school 1 and rotated for succeeding schools.

The introduction and directions given the groups were essentially the same at each school. Within each school the directions differed only as necessary to indicate certain procedures unique to a treatment (sample directions given in Appendix). For example, the immediate participation group had to be specially directed to answer only a certain part of the test after the showing of the corresponding film sequence.

The introductory "set" given the students for the post-test was quite different from that given for the retention test. The post-test was introduced as a "test of the film, not of the student," and the feedback phase was to "help the student learn the correct answers." The retention test, on the other hand, was introduced as a test of the student to "see how much he could remember of what he had learned two weeks before." (Copies of both tests and both sets of instructions are given in the Appendix.)

Procedure for the four utilization conditions differed as follows:

1. Delayed participation--delayed feedback (DP-DF).
   a. Film shown in entirety.
   b. Test taken in entirety.
   c. Correct answers given the next day.

2. Delayed participation--immediate feedback (DP-IF).
   a. Film shown in entirety.
   b. Test taken in entirety.
   c. Correct answers given after each item answered.

3. Immediate participation--delayed feedback (IP-DF).
   a. Film shown through the first sequence.
   b. Test taken on the first sequence.
   c. Steps a and b repeated for other six sequences.
   d. Correct answers given the next day.

4. Immediate participation--immediate feedback (IP-IF).
   a. Film shown through the first sequence.
   b. Test taken on the first sequence.
   c. Correct answers given after each item answered.
   d. Steps a, b, and c repeated for other six sequences.

These four utilization conditions were administered for both the conventional film and the programed film.

Administering the eight conditions (two films by four utilization conditions) simultaneously to as many groups in separate rooms proved impossible in schools 1, 2, and 3, where there were only four seventh grade classes and hence four rooms available. Consequently, within each room two treatment conditions were administered together--immediate feedback and delayed feedback. This was possible because of differences in the test booklets which were described in the previous section on test construction. In school 4 there were eight classrooms, and thus each of the eight groups could receive a treatment condition separately.

These differences in testing procedure between schools were not judged to be such as to influence treatment effects differentially.

The administration of the feedback factor at school 4 was appreciably different from the others. In schools 1, 2, and 3 feedback, both immediate and delayed, was given to each subject individually by means of his test booklet (see Figures 26-29). However, in school 4 feedback, both immediate and delayed, was given orally by the instructor to the whole group. The content of the feedback was unchanged, it was given item by item as with the other method, and it was applied equally to both treatment conditions for the feedback factor. This change in feedback procedure was motivated by a desire to try something that did not require a special test book and hence could be used under ordinary classroom conditions. There resulted a confounding of schools and method of providing feedback. However, there was no reason to expect that any differences between school 4 and schools 1 and 2 would be due to schools per se. Rather, it was considered that any such differences could reasonably be attributed to the difference in feedback procedure itself. This will be examined further in the section Analysis of Retention Test Data.

Data Obtained and Method of Analysis

The following data were obtained for each subject: I.Q., number of answers correct on each test, number of correct answers to verbal items and to pictorial items for each test. These data were punched on IBM cards for processing on the 709 computer. Two computer programs were used, BIMD 20 and SHARE 1212, both of which do analysis of variance as well as covariance. Each of these programs had certain advantages; more important, the two provided a needed check on each other.

A total of more than 400 subjects began the experiment, but the N for statistical analysis was 336, the losses being due in part to absenteeism during some phase of the experiment and in part to the dropping of subjects to achieve proportionality of cell frequency. This yielded 42 subjects for each of the eight treatment conditions.

As previously outlined, the basic design was 2 x 2 x 2, involving treatments for the three factors--film, participation, and feedback--each being at two levels, conventional process and programing process. In addition, the subjects in each condition were apportioned among three I.Q. levels (low, average, and high). The resulting 2^3 x 3 design was replicated at four schools.

It is believed that the design and procedure employed permitted adequate control of possible sources of error. Type S errors (subject differences) were controlled by random assigning of available subjects to treatments, by the relatively large sample size, and especially by the treatments-by-levels design. Type G errors (treatment groups) were controlled by the random assignment of rooms and instructors for each treatment and by replication of the experiment in four schools. Type R errors (replication) were controlled by the number of replications and the care exercised to standardize procedures for each (15:9-11).

Analysis of Post-Test Data

The experimental hypotheses under test were as follows:

1. The mean test score for subjects learning from the programed film will be greater than the mean test score for subjects learning from the conventional film.

2. The mean test score for subjects encountering the utilization situation where participation is immediate (programed) will be greater than the mean test score for subjects in the situation where participation is delayed (conventional).

3. The mean test score for subjects encountering the utilization situation where feedback is immediate (programed) will be greater than the mean test score for subjects in the situation where feedback is delayed (conventional).

It had been decided that significance at the 5 per cent level would be required for rejection of the null hypotheses. The critical values of F for this would be 3.89 at 1 and 200 df, 3.04 at 2 and 200 df, and 2.65 at 3 and 200 df (2).

Table 2 summarizes the analysis for data from the post-test. Of the three treatment factors, two showed differences that were significant beyond the .001 level of confidence: the factors for Medium (M) and Feedback (F). In both cases the differences were in the expected direction, i.e., favoring the programed process over the conventional. Thus, the evidence leads to rejection of the null hypotheses corresponding to experimental hypotheses 1 and 3 for the post-test data.

The main effect for Participation (P) failed to reach significance at the 5 per cent level, although the difference between means was in the hypothesized direction. It should be remembered that participation versus nonparticipation was not under test in this study, but rather the immediate versus delayed timing of participation. Under the conditions of this study these two types of participation were not sufficiently different in effect for rejection of the null hypothesis corresponding to experimental hypothesis 2.

Table 2. Summary of Analysis for Data from Post-Test.

Source of Variation	df	SS	MS	F
Treatment factors				
Medium (M)	1	798.58	798.58	26.57***
Participation (P)	1	72.42	72.42	2.41
Feedback (F)	1	874.29	874.29	29.09***
Classification factors				
Ability (A)	2	2645.91	1322.95	44.02***
School (S)	3	423.82	141.27	4.70**
Interactions				
M x P	1	66.96	66.96	2.22
M x F	1	51.85	51.85	1.72
P x F	1	0.29	0.29	0.01
M x A	2	209.46	104.73	3.48*
P x A	2	2.48	1.24	0.04
F x A	2	30.07	15.03	0.50
M x S	3	90.28	30.09	1.00
P x S	3	161.13	53.71	1.78
F x S	3	178.12	59.37	1.97
A x S	6	248.56	41.42	1.37
M x P x F	1	19.04	19.04	.63
Other	62			
Within cells	240	7211.53	30.04	
Total	335	14847.57		

* Significant at .05
** Significant at .01
*** Significant at .001

The classification factors for Ability (A) and School (S) showed statistically significant main effects, but this is of peripheral interest in this study.

None of the two-way interactions were significant except that between Medium (M) and Ability (A). Examination of the associated means in Table 3 suggests that the interaction may be due to the fact that whereas there is a positive acceleration of mean test scores with increasing ability level for the programed film, there is a negative acceleration for the conventional film. The effect is particularly noticeable for the high-ability subjects, whose superiority over the average-ability students is much more marked for the programed film than for the conventional. _t_-tests of the means in each column show all differences to be significant except that between average- and high-ability students encountering the conventional film.

Table 3. Post-Test Means for the Medium x Ability Interaction.

Ability (I.Q.)	Medium	
	Conventional	Programed
Low	20.5	22.9
Average	24.1	25.6
High	25.9	31.2

The three-way interaction for the three treatment factors is not significant. Other three-, four-, and five-way interactions involving the classification factors are not reported because of their marginal interest and their difficulty of interpretation.

Table 4 gives the means for each level of each treatment. The mean for the programed medium showed a superiority of 13 per cent over that for the conventional medium. The mean for the immediate feedback condition was 14 per cent greater than the mean for the delayed feedback condition.

Table 4. Post-Test Means for Each Level of Each Treatment.

Treatment and Level	Mean
Medium	
Conventional	23.49
Programed	26.57
Participation	
Delayed (conventional)	24.57
Immediate (programed)	25.50
Feedback	
Delayed (conventional)	23.42
Immediate (programed)	26.64

To find the best treatment combination for the post-test, the means for each were examined (see Table 5). The lowest mean (21.1) was for the all-conventional combination, i.e., conventional medium, delayed participation, and delayed feedback. A t-test showed this mean to be significantly different from all others at the 5 per cent level. The highest mean (28.8) was for the all-programed combination, i.e., programed medium, immediate participation, and immediate feedback. By t-tests this mean was found to be significantly different from all others except for that of the treatment combination that was programed for medium and feedback but conventional for participation (28.3). This is consistent with the no-difference finding for the main effect of the participation factor.

Table 5. Post-Test Means for Treatment Combinations.

Treatment Combinations			
Medium	Participation	Feedback	Post-Test Means
Conventional	Delayed	Delayed	21.1
Conventional	Delayed	Immediate	24.1
Conventional	Immediate	Delayed	23.4
Conventional	Immediate	Immediate	25.3
Programed	Delayed	Delayed	24.8
Programed	Delayed	Immediate	28.3
Programed	Immediate	Delayed	24.4
Programed	Immediate	Immediate	28.8

Analysis of Retention Test Data

Table 6 summarizes the analysis for data from the retention test.

The main effects for classification factors, ability and school, are again significant but of no particular consequence to this study. Treatment factors, on the other hand, did not approach the necessary F-ratio of 3.89 at 1 and 200 df to permit rejection of any of the null hypotheses at the 5 per cent level. None of the two-way interactions were significant nor was the three-way interaction for the three treatments.

What happened to the differences between means for medium and for feedback that were different by a highly significant .001 on the post-test two weeks earlier? The possibility of some spurious factor entering for one replication was considered. However, a separate analysis for each school revealed no such effect, as Table 7 shows. None of the treatment factors achieved significance in any of the replications.

Mean scores for each treatment condition, Table 8, provide a basis for further exploration of the no-difference finding on the retention test.

Table 6. Summary of Analysis for Data from Retention Test.

Source of Variation	df	SS	MS	F
Treatment factors				
Medium (M)	1	14.16	14.16	0.56
Participation (P)	1	20.50	20.50	0.81
Feedback (F)	1	1.86	1.86	0.07
Classification factors				
Ability (A)	2	5347.02	2673.51	106.47***
School (S)	3	1075.42	358.47	14.27***
Interactions				
M x P	1	73.36	73.36	2.92
M x F	1	0.86	0.86	0.03
P x F	1	7.14	7.14	0.28
M x A	2	45.07	22.53	0.89
P x A	2	11.45	5.72	0.22
F x A	2	34.38	17.19	0.68
M x S	3	141.26	47.08	1.87
P x S	3	71.28	23.76	0.94
F x S	3	52.73	17.57	0.70
A x S	6	269.58	44.93	1.78
M x P x F	1	48.00	48.00	1.91
Other	62			
Within cells	240	6026.01	25.10	
Total	335	14748.49		

***Significant at .001

Table 7. Analysis of Retention Test Data by Replication (School).

	F-Value for Four Replications			
Source of Variation	1	2	3	4
Medium	0.01	1.42	4.23	1.56
Participation	0.46	0.47	3.45	0.19
Feedback	0.15	0.88	0.28	0.94
Critical ratios	4.04	4.04	4.26	3.94

Table 8. Post-Test and Retention Test Means for Each Treatment Level.

Treatment Condition	Test Means 1. Post-Test	 2. Retention Test	Loss from 1 to 2
Medium			
Conventional	23.49	21.75	-1.74
Programed	26.57	22.16	-4.41
Participation			
Conventional (delayed)	24.57	22.20	-2.37
Programed (immediate)	25.50	21.71	-3.79
Feedback			
Conventional (delayed)	23.42	22.03	-1.39
Programed (immediate)	26.64	21.88	-4.76

It can be seen that the greater mean for the medium factor on the post-test (26.57 for the programed condition) was the one that suffered the greatest loss on the retention test (-4.41). In fact, it was true of all three factors that the "best" condition (programed) in the post-test lost the most severely in the retention test, the losses being 4.41, 3.79, and 4.76, respectively.

An exception to this generalization occurred in school 2, where a third condition for the medium factor was tested. As noted in Chapter II, the programed film was the same length as the conventional for all hypothesis testing, except that a longer programed version was tested in one school. The programed-long version was the same as the programed-regular version, except that the scenes were longer and the narration was paced more slowly. No new information, either pictorial or verbal, was added.

Data for the programed-long condition were not included in the main analysis but were part of a separate analysis for school 2 alone. Table 9 shows the main effects for retention test data in school 2. Critical F values are 3.98 for 1 and 70 df, 3.13 for 2 and 70 df, and 2.50 for 4 and 70 df (2).

Table 9. Analysis for Retention Test Data in School 2 with Three Conditions for Medium.

Source of Variation	df	SS	MS	F
Treatment factors				
Medium (M)	2	331.72	165.86	8.55***
Participation (P)	1	53.48	53.48	2.75
Feedback (F)	1	75.00	75.00	3.86
Classification factor				
Ability (A)	2	1267.72	633.86	32.67***
Interactions				
M x P	2	44.46	22.23	1.15
M x F	2	77.17	38.58	1.99
P x F	1	45.37	45.37	2.34
M x A	4	141.55	35.39	1.82
P x A	2	38.46	19.23	0.99
F x A	2	50.17	25.08	1.29
M x P x F	2	26.35	13.18	0.68
Other	14			
Within Cells	72	1396.67	19.39	
Total	107	3962.00		

***Significant at .001

As Table 9 shows, the null hypothesis for the medium factor (three conditions) may be rejected at the 5 per cent level for the retention test data in school 2. It is noteworthy that this factor showed no significant difference in the over-all analysis of retention test data either for all schools combined or for school 2 alone when the programed-long film data were excluded. This leaves the programed-long film as the logical source of the significant difference.

The means for each treatment are shown in Table 10, which reveals the same general trend, previously noted, for the condition having the higher initial mean to be the one having the greater loss. The exception to this trend is the programed-long condition, which lost very little more than the conventional condition for medium.

A t-test of the retention test data for school 2 shows the mean for the programed-long version to be different from the means for both the conventional and the programed-regular versions by an amount that is statistically significant at the .05 level. Considerable importance will be attached to this finding in the chapter Discussion. However, this statistic is subject to more error than those based on all the schools because the sample is smaller (108 subjects) and there was no replication that included the programed-long version. However, the statistic retains the advantage for S errors of a treatments-by-levels design.

Table 10. Means for Treatment Levels in School 2, Including the Programed-Long Medium.

Treatment	Post-Test	Retention Test	Loss
Medium			
Conventional	22.63	19.50	-3.13
Programed-regular	26.38	20.80	-5.58
Programed-long	27.02	23.69	-3.33
Participation			
Conventional (delayed)	25.03	22.03	-3.00
Programed (immediate)	25.66	20.62	-5.04
Feedback			
Conventional (delayed)	22.42	20.50	-1.92
Programed (immediate)	28.27	22.16	-6.11

A t-test of the means for participation is not significant and neither is that for feedback means.

At this point we shall return our attention to the combined data (all schools) for the retention test. Table 11 compares the means for each of the eight treatment combinations as they occurred in the retention test. The means are so narrowly distributed that the only t-test of significance is that between the lowest and highest, which, according to Lindquist (15:95), is a dubious test and one for which a special t-table would be required. Thus, there are no statistically significant differences among the eight treatment combinations for the retention test.

The relationship of ability (I. Q.) to the previously noted drop in scores from post-test to retention test is shown in Table 12. As is apparent, the higher ability subjects not only learned more initially but they forgot less in the intervening two weeks. All means within each column are significantly different at the 5 per cent level according to t-tests.

Table 11. Retention Test Means for Treatment Combinations for All Schools.

Treatment Combinations			
Medium	Participation	Feedback	Retention Means
Conventional	Delayed	Delayed	21.4
Conventional	Delayed	Immediate	21.6
Conventional	Immediate	Delayed	22.3
Conventional	Immediate	Immediate	21.6
Programed	Delayed	Delayed	23.4
Programed	Delayed	Immediate	22.3
Programed	Immediate	Delayed	20.9
Programed	Immediate	Immediate	21.9

Table 12. Means at Each Ability Level for Post-Test and Retention Test for All Schools and Treatments.

	Test		
Ability (I.Q.)	Post	Retention	Loss
Low	21.69	17.35	-4.34
Average	24.85	21.45	-3.40
High	28.56	27.08	-1.48

The mean at each school for all conditions combined may be of some interest (shown in Table 13).

Table 13. Post-Test and Retention Test Means by Schools.

School	Post-Test	Retention Test	Difference
1	24.80	19.92	-4.88
2	24.51	20.15	-4.36
3	27.77	24.87	-2.90
4	24.50	22.92	-1.58

School 3, with the highest initial mean score, also had the highest retention score. Both were significantly different from the scores for the other three schools. Subjects from school 3 were the only ones who had had general science; thus, they may have had a greater initial knowledge of the concepts.

School 4, with the least loss between initial and retention scores, is of interest because, as noted previously in the section on testing procedure, it differed from the others in only one relevant way, as far as is known, and that is in the method of giving feedback. Feedback for both treatment conditions was given orally and to whole class groups, whereas in schools 1, 2, and 3 feedback was given individually in the test booklets where each subject read it to himself. An analysis of the means in Table 13 (except those previously discussed for school 3) showed that while the mean for school 4 was not significantly different from that for schools 1 and 2 on the post-test, it was significantly different ($p > .01$) from schools 1 and 2 on the retention test. However, because there was a confounding of schools and feedback procedure, it was impossible to attribute the obtained significant difference to the feedback procedure alone. A further analysis is given in Table 14. For this analysis, data from schools 1 and 2, having one feedback procedure, were combined for comparison with school 4, having the other.

Table 14. Analysis of Post-Test and Retention Test Means for Feedback at Schools 1, 2, and 4.

	Post-Test			Retention Test		
	Schools			Schools		
Source of Variation	1 and 2	4	Difference	1 and 2	4	Difference
Immediate feedback	27.1	25.5	1.6	20.4	22.5	2.1*
Delayed feedback	22.3	23.5	1.2	19.7	23.3	3.6*
Difference	4.8*	2.0*		0.7	0.8	

*Significant at .05

Notice that with regard to the main effect for feedback, immediate versus delayed, the post-test mean for schools 1 and 2 was comparable to that for school 4; i. e., _t_-tests for both schools showed the mean for the immediate feedback condition to be greater by a significant amount than that for the delayed. Further, there were no significant differences between the means for the schools at either level of the feedback factor. Thus, the significant post-test differences are related to treatments rather than to schools.

However, for the retention test just the opposite was the case. There were no significant differences between means for the treatments, while the differences between school means were significant, with that for school 4 being the greater. In brief, the treatments that were significantly different initially were not significant two weeks later.

This is consistent with the general finding for main effects in this study. On the other hand, the schools that were not significantly different initially were significantly different two weeks later. This is consistent with the contention that, in spite of the confounding of schools and feedback procedures, the differences found on the retention test between schools 1 and 2 together and school 4 are attributable to the difference in feedback procedure, with that used at school 4 being the superior.

A comparison of verbal and pictorial test items may be of interest. In terms of over-all mean score on the retention test, 54 per cent of the verbal items was answered correctly and 55 per cent of the pictorial. The distribution of responses by the three ability levels seems comparable for both verbal and pictorial items, as shown in Table 15.

Table 15. Mean Retention Test Scores for Pictorial and Verbal Test Items by Subjects of Three Ability Levels.

Ability (I. Q.)	Retention Test Means	
	Verbal Items	Pictorial Items
Low	11.6	5.7
Average	14.4	7.0
High	18.1	8.9
Possible score	27	13

The retention test items are included in the Appendix.

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CHAPTER IV

DISCUSSION

This study differed from most related studies in that it did not seek to test film versus no film, participation versus no participation, or feedback versus no feedback. These issues have been explored and the general contribution to learning of film, participation, and feedback has been fairly well established. This study dealt, instead, with types or levels of these three factors, the programed versus the conventional types, as applied to the educational film medium.

Post-Test Results

Medium (film types). For the comparison of film types, conventional versus programed, an initially significant difference ($p > .001$) was found in favor of the programed. As noted in Chapter II, this film was programed in the sense that it was repeatedly tested with learners, and the feedback obtained was used in successive modification of the film program. Moreover, information was given a small bit at a time. The gain in mean score of 13 per cent over the conventionally produced film is not sufficient to start a revolution in education,but it does represent an improvement in learning of a magnitude that would have practical significance today and increasing strategic importance as the problems of raising the quantity and quality of learning are approached with more precision in our school systems. Further, this is a gain over a highly successful educational film that had been very carefully designed with the expert guidance of teachers and subject-matter specialists.

The research literature on film variables is not large. That concerned with programed films is especially limited, although the volume of research will be augmented by several Title VII studies (not yet completed at the time of the present report) dealing with the programing of TV, slides, and films. Levonian (14) reports an audience-tailored film made from scenes that had been pretested with a sample from the intended audience. That audience's opinion of each scene was gathered, factor analyzed, and used to design a film intended to change those opinions. The effectiveness of this procedure was not reported, though it has an inescapable validity.

Gropper (5) pretested two TV lessons in science with a sample class and used the feedback to revise the lessons. A subsequent experimental comparison showed the revised version effecting a 10 to 14 per cent improvement over the original in number of correct responses to objective and essay items on an achievement test. This finding for TV closely parallels that of the present film study.

Participation. The two types of participation failed to produce differences in learning that were statistically significant as measured by the post-test. This finding may at first seem to run counter to the extensive amount of research evidence in support of active participation in learning. A review of this literature several years ago stated that "no other [film] variable has elicited such general confirmation as a means of facilitating learning from AV Communication materials" (1). However, participation can be of many kinds, including oral responses during a film, perceptual-motor responses, written responses to questions, note taking, and even covert (mental) practice. Studies employing the written answer form of participation varied markedly in the frequency of participation. With some, participation occurred only once and was either just before or just after the instruction. In others it was interspersed throughout the instruction at intervals as small as 32 seconds on the average (13). For the present study the interval between participations averaged 2 1/2 minutes. The one study that made the same comparison as the present one--immediate (interspersed) versus delayed (immediately afterwards)--found no significant differences either (7). In the present study the comparison was one of participation 7 times versus 1 time, or every 2 1/2 minutes versus every 17. This is a rather crude comparison. The search for an optimum value should certainly sample a much greater number of values. The grounds for making such a search are evident, not only in the film literature but also in the programed instruction literature, in which the search for the analogous optimum size-of-step is still being pursued. Thus the problem can be conceived of two ways: how much information (size of step) should be presented to the learner before he actively participates, or how immediately after the presentation of information should the learner actively participate? Both questions need more definitive answers.

Another aspect of the present study that should be considered in future work is the extent of each participation event. For this study there were from four to seven questions each time, while for the other comparable studies there seems to have been only one question. One ramification to be considered is the effect on the learner of the interruption caused by extended participation. There is a possibility that the rather long time taken for each participation caused such a serious break in the learner's continuity of thought that he was not fully ready to start again where the film had left off. Although all the breaks were at transition points between major concepts, a more adequately programed film might have launched into each succeeding unit with a brief re-orientation.

Feedback. The third factor, feedback, yielded significant (>.001) differences on the post-test between means for the immediate versus delayed conditions, with that for the immediate feedback condition being the greater. This difference amounted to a 14 per cent gain over the conventional condition.

This finding cannot be directly compared with the other film studies on feedback, which rather uniformly compared its presence with its absence and found its presence significantly superior. One study did postpone feedback until after the film but did so for all conditions (8). Otherwise, the immediate versus delayed issue seems to have been avoided in film research, perhaps because experimental psychology has already overworked it. Immediate feedback, expressed as a reinforcing stimulus, has repeatedly been shown to be important, and under some conditions its occurrence must be within a few seconds. Nonfilm studies in programed instruction seem to favor immediate feedback over delayed, though not all studies support this finding (16).

In this study the immediate feedback condition was one that provided the learner knowledge of the correct answer within a few seconds after his response. For the delayed feedback condition there was a period of approximately twenty-four hours intervening. The immediate feedback condition gave means that were uniformly superior to the delayed whether the film was conventional or programed and whether the participation was immediate or delayed.

In a general assessment of the merits of participation and/or feedback in this study, one should not overlook the fact that in spite of there being no difference between immediate participation and delayed, the value of participation per se remains unchallenged. Further, participation was essential, if for no other reason than to provide an overt response concerning which the highly effective immediate feedback could be given.

For most of the film studies of feedback, the correct answers were built into the film. For three of the schools in this study, the answers were printed in the test booklets. Both procedures require more expensive and complicated materials than the method used in school 4, which may also be the more effective. The reader may recall from Chapter III that in this instance the procedure was for the students to write their answers as they would for an ordinary test, except that after all had responded to a particular item (as evidenced by their looking up at the instructor), it was read aloud by the instructor along with the correct answer. This group feedback method, while lacking the advantage of self-pacing, did engender considerable enthusiasm among the students. There was an unanticipated element of suspense until the correct response was given, and its reinforcing effect was frequently evident--smiles, looking around at other students, etc. None of this kind of involvement seemed to be generated by the individual feedback method. In fact, the students in other schools were repeatedly reminded of the importance of checking the correct answer because they so often appeared to give the correct answer only a casual glance before flipping on to the next question. School 4 did not perform above schools 1 and 2 in the post-test but did significantly better than they for all treatments combined on the retention test. However, it is not conclusive that the difference in feedback procedure accounted for the over-all superiority in the retention test.

Retention Test Results

None of the experimental conditions were associated with significant differences on the retention test. This was true of all the data comparing the conventional and programed films of equal length, whether the data were for the four schools together or for each one separately. It was true whether an analysis of variance in a treatment x levels (I. Q.) design was used or whether a covariance analysis was used with I. Q. being the covariant. The one exception was associated with a longer programed film, which was tested in addition to the other two films at school 2.

The drop in the relative superiority of the seventeen-minute programed version over the seventeen-minute conventional version from 13 per cent to 2 per cent was astonishing and stimulated a review of the literature on retention. The first thought was that there might be an isomorphic relation between learning curves and forgetting curves. If one group learned at a faster rate (learned more in the same time, which is what the programed film subjects did), perhaps they also would forget at a similarly fast rate; i.e., the slope of the learning curve might be repeated in the retention curve. No reports were found on laboratory studies of the psychology of learning that made direct comparisons of learning and retention curves for the same tests and subjects. Furthermore, only a few laboratory studies on retention used the method of "equal opportunity to learn" as the starting point. (Most had the subjects learn the same initial amount or at least to the same criterion, which is not analogous to the method of the present study.) However, there was the general finding of a positive, though not always high, correlation between initial scores and retention scores on a recall test (4).

A statement in the Knowlton-Tilton study (12:57) was the most relevant. "The experimental group learned more, forgot more, and remembered more. It is the usual finding for those who learn more to remember more even though they forgot more." This observation is not as contradictory as it sounds. The programed film group, for example, learned more (13 per cent more), forgot more (an average of 4.4 items as compared to the 1.7 for the conventional film), and remembered more (just barely, 2 per cent more). (However, the finding that those who learn more also forget more does not hold where the greater learning is a function of ability (Table 12). In general, the high-ability students in this study learned more and forgot less.) A perusal of a number of other teaching methods studies revealed the same tendency for the initially better treatment condition to exhibit the greater loss after a time delay. Often there was no difference between experimental conditions on a retention test; and the data, if available, were barely mentioned. It would seem that rather than being avoided, such disturbing facts should be faced and subjected to further research. If the impressive and statistically significant initial gains in achievement cannot be detected a few weeks later, of what importance are they? Of course, the evidence is that re-learning the material will be more efficient another time, but that may often be of dubious merit.

It is plausible that several factors in the present study contributed to the drop in mean scores from post-test to retention test. For one thing, the two tests did not correlate so highly (.75) as parallel forms should have correlated. One thing that may have contributed to this was the difference in order of items, the post-test being in film order and the retention test being in random order. Insofar as the grouping of items on a single concept might facilitate recall, the post-test would be expected to yield higher scores. Moreover, the different "set" given for the two tests may have had its effect. As noted in Chapter III, the post-test was introduced as a "test of the film," while the retention test was introduced as a test of the learners' ability to recall. Whether these differences were unequal in effect across treatment conditions can only be conjectured, but they do help explain the over-all drop in mean scores on the retention test.

A general loss on the retention test would be expected because the intervening activity between learning and recall was, by design, filled with other learning experiences. In contrast to the usual classroom situation where several successive periods devoted to a concept are preceded by adequate preparation and followed by adequate review, the experimental situation was for the student a concentrated period of learning which he experienced in isolation from preceding and succeeding events. This kind of situation probably accounts for much of the retention loss in experiments like the present one which deal with a single short unit. Studies extending over a semester of work should be less subject to the rapid forgetting phenomenon. However, the mere isolation of the learning in this case fails to account for the differential rate of forgetting, where those who learned more as a function of certain treatments also forgot more.

A more plausible account can be given in the context of massed versus spaced practice or, more indigenous to the film literature, fast versus slow "rate of development" (10). Particular weight is given this position by the findings for the long programed version. This version employed the same scenes as the regular programed version, but the scenes were longer. Moreover, the long version narration was the same as the regular except that it was slower paced and had longer pauses. Thus, the long (21 minutes) and regular (17 minutes) programed versions were comparable to the slow (18 minutes) and fast (11 minutes) rates of development employed in the Jaspen study (10). However, the Jaspen slow film had additional scenes as well as longer ones, and it is not clear whether the narration was modified in wording or just pacing. Further, the Jaspen film taught a psychomotor skill (assembling a breech block), while the film for this study taught verbal responses to concepts of time. Both studies yielded statistically significant differences favoring the slower rate of development.

The related problem of verbalization level was also studied by Jaspen (11). His medium level (97 words a minute) was statistically superior to his very low level (45 words a minute) but not to his high level (142 words a minute). The levels for the present experiment were 117 for the conventional version, 158 for the programed-regular version, and 130 for the programed-long. Of these, the middle level, 130 words a minute, was significantly superior, at school 2, to the other two on both the post-test and retention test. However, these differences are not solely attributable to verbalization level. The conventional and programed versions differed markedly in both pictorial and verbal content; and, although the two programed versions were identical in content, the long version allowed the learner more time to study the pictures as well as the words.

The tendency discussed earlier for the experimental condition to gain more but lose more did not hold for the long programed film. It showed an initial gain over the conventional version of 19 per cent, and two weeks later the difference was essentially the same, a 21 per cent superiority.

It does seem to be the case that classroom films have tended to be packed with information and hence employ a fast rate of development. This is supported by the findings reported here as well as by the often confirmed finding that showing a film twice yields a significant increment in learning. Discussions of such results have frequently recommended the showing-twice method rather than the production of longer and more slowly paced films. This appears logical, but let us suppose that a slow-paced film is 1 1/2 times the length of a fast-paced one and is proved to be as effective as two showings of the fast-paced one. The savings in class time for the slow-paced film are apparent. If the slow-paced film were 15 minutes long, the savings over the double showing of the 10-minute film would be 5 minutes plus rethreading time. A further saving for the longer film is seldom considered. If the shorter film is shown twice each time, it will wear out twice as fast. Thus in terms of print cost the investment in one 15-minute film would be compared to that in two prints of the 10-minute film, to the obvious advantage of the 15-minute slow-paced version.

Another possible relationship of import to future studies was the retention test difference apparently attributable to the change in procedure for giving feedback. As described in Chapter III, feedback was given to each subject individually in his test booklet at all except school 4, where it was given orally to the whole class. Coincident with this was the finding of no significant difference among means for schools 1, 2, and 4 on the post-test but a significant difference favoring school 4 on the retention test. Because of the confounding of factors, this finding is not known to be free of extraneous effects associated with the different schools. However, the observed change from post-test means to retention test means for these schools seems of sufficient magnitude to justify further experimentation with methods of giving feedback in the classroom situation. The evidence suggests that the feedback given orally and item for item by the teacher in a group testing situation may appreciably facilitate learning, particularly if given immediately after the students have responded.

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CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Under the particular conditions and limitations of this study, several conclusions can be drawn.

1. Programing processes for the design of a classroom film yielded a product that was educationally superior to that from conventional processes, particularly when the film's length and rate of development were allowed to find their optimum level based on feedback from learners.

2. Self-instructional processes for the use of educational films were superior to conventional processes, but it was the immediacy of the feedback to learners after their active participation that contributed most to learning. It did not matter whether the learners' participation was immediate (during the film) or afterwards.

It is probably indicative of the method of science that one of the most frequently and positively asserted recommendations is that more research be done. Several such recommendations have already been made in the previous chapters but will be repeated here.

1. The search should be continued for the optimum rate of development or size of step for each type of learning task and each category of learner.

2. Further work should be done on the retention of conceptual learning as a function of different teaching methods and materials, with particular attention to the factors that operate to aid or deter retention.

3. The parameters of film design by the programing process are as yet very nebulous. Variations and combinations of the processes need to be tried. One such alternative would be a combination of feedback from both expert and learner.

4. Further exploration should be done on different methods of giving feedback, particularly comparing individual and group methods.

5. **Research in pursuit of the relevant cue is probably the most needed of all. What cue types are related to what response types for what audience? This question is in the communication domain. A related one is from the substantive domain. What cue types characterize or are criterial for what types of concepts or subject-matter structures? Together, the two questions mean that each body of knowledge (or each way of knowing) and each type of learner have unique attributes that must somehow be brought into harmony before learning can take place optimally. It is the professed role of the AV communicator to know the probabilities involved and to prescribe the best cues for the particular learner and particular subject matter. A great deal more research in this context must be done.**

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APPENDIX 1

INSTRUCTIONS TO SUBJECTS WHOSE PARTICIPATION WAS DELAYED

[Information in parentheses was for the instructor]

1. (Call roll)

(Absentees - note on roster)

(Extra people - if name is on roster for another section, send to that room; otherwise add name to your roster.)

2. You are participating today in a research study being done by the Indiana University Audio-Visual Center in cooperation with the U.S. Office of Education. We are interested in finding out how much students like yourselves can learn from educational films that are made and used in different ways. The film you will see is about time -- how scientists determine time, how we keep time, how the world was divided into zones of standard time, etc.

After the film has been shown, you will answer a number of questions about it. This is necessary in order to find out how effective the film is. So it is really the film that is being tested, not you. However, in order to give the film a fair test, you will need to pay attention to it and answer the questions as well as you can.

Are there any questions?

3. (Pass out answer sheets, special pencils, and books.)

(Each book goes to the person whose name is on it.)

You have each been given an answer sheet and a special pencil. Using the pencil, fill in the blanks for (hold up sheet and point) your name and the date; your school; your date of birth, age, and sex; and your class and section, such as 7-1, 7-2, etc. Where it says "Name of Test" fill in as follows:

If your test is blue bound, its name is ______________________________.

If it is black bound, its name is ______________________________.

(Put both names on blackboard for clarity.)

Put that name on your answer sheet here (point).

Now please read the directions on your answer sheet. (Pause) Notice the sample question (point to on sheet). It says "Chicago is" and the answer is "D, a city." See how the space between the dotted lines has been filled in under "D." Any questions? Be sure you use the special pencil, and keep your marks between the dotted lines.

4. Please read the instructions on the top pink sheet of your booklet, but do not turn it over yet. (Pause) (Only pink sheets should be showing.) Any questions? (Reread aloud the last paragraph beginning "Sooner or later . . . ")

The reason for giving you the answers is to help you learn them. So if you receive the answers today, study them carefully, especially the ones you missed. If you receive them tomorrow, you can study them then. (If you get questions about a possible other test later, you "don't happen to know about that.")

You may turn over the pink sheet. Notice that the buff sheet is folded. Open it out like this. You will find many other sheets like this in your book that will have to be opened out, so don't be fooled by them.

Here are two sample questions on one page. Some pages later on in the book will have three questions, so be careful to answer all the questions on each page. Now go ahead and try the two sample questions numbered 50 and 51. (Pause) (Only buff sheets should be showing.)

What answer did you choose for number 50? (D?)

Fine. Be sure to choose only one answer.

What space on the score sheet did you fill in?

(Should be beside #50 and under D, the fourth space over.)

So be sure to put your answer on the answer sheet beside the number that matches the number of the question. If you put your answer in the wrong place this time, erase it completely and change it to the correct place.

What answer did you choose for number 51? (B?) Very good.

Incidentally, your questions will have A, B, C, or D answers like this. So you will not be using the "E" column on your answer sheet.

5. (Show the film)

(There is a spare projector and film in the school office in case of serious breakdown.)

Remember, answer each question as best as you can and then turn the sheet over. After you turn a question sheet, please do not change your answer and do not turn the question sheet back. Remember it's the film that is being tested, not you. (Pause)

Two more little problems. Please do not mark your books, and keep them flat and open on your desk like this so the pages will turn easily.

You may now turn over to the next page and answer question 1, then 2, and so on till you have answered all the questions.

6. (Immediately after the last student has finished the last item, #40, send your projectionist to notify the school office.)

Are all 40 questions answered? Did you find any repeated or skipped questions in your book? (If so, mark book on top white sheet.)

(Collect papers, pencils, and books. Turn room back to the teacher but permit no discussion of the film.)

(When the bell rings, you're done and can pack up and leave.)

PRECEDING PAGE BLANK- NOT FILMED

APPENDIX 2

INSTRUCTIONS TO SUBJECTS WHOSE PARTICIPATION WAS IMMEDIATE

[Information in parentheses was for the instructor.]

[Steps 1-4 are the same as in Appendix 1.]

5. (Show first part of film - up till screen goes blank and light.)

(There is a spare projector and film in the school office in case of serious breakdown.)

Remember, answer each question as best as you can and then turn the sheet over. After you turn a question sheet, please do not change your answer and do not turn the question sheet back. Remember it's the film that is being tested, not you. (Pause)

Two more little problems. Please do not mark your books, and keep them flat and open on your desk like this so the pages will turn easily.

You may now turn over to the next page and answer question 1, then 2, and so on till you have answered all the questions up to the next pink sheet. Then wait for further instructions.

6. (Show second part of film - up till the screen again goes blank and light.) You may now turn over the top pink sheet and answer the next group of questions. Continue till you come to the next pink sheet and then wait.

Keep checking to be sure your question numbers match your answer numbers.

(Repeat this cycle till film is done, i.e., show next part of film till screen goes blank and light, give instructions to answer next group of questions, etc.) (In case there is any problem, you should know that the questions and film are divided as follows:

Part 1 on Sundials - Questions 1-4

Part 2 on Standard Time - Questions 5-11

Part 3 on International Date Line - Questions 12-18

Part 4 on Daylight Saving Time - Questions 19-25

Part 5 on Scientific Time - Questions 26-30

Part 6 on Pendulum - Questions 31-35

Part 7 on Rate and Frequency - Questions 36-40)

7. (Immediately after the last student has finished the last item, #40, send your projectionist to notify the school office.)

Are all 40 questions answered? Did you find any repeated or skipped questions in your book? (If so, mark book on top white sheet.)

(Collect papers, pencils, and books. Turn room back to the teacher but permit no discussion of the film.)

(When the bell rings, you're done and can pack up and leave.)

APPENDIX 3

INSTRUCTIONS TO SUBJECTS IN SCHOOL 4 WHOSE PARTICIPATION WAS DELAYED

[Information in parentheses was for the instructor.]

[Steps 1-4 are the same as in Appendix 1.]

5. (Show the film)

(There is a spare projector and film in the school office in case of serious breakdown.)

Remember, answer each question as best you can but don't turn the page till instructed to do so. After you answer a question, please do not change your answer and do not turn the question sheet back. Remember it's the film that is being tested, not you. (Pause)

Two more little problems. Please do not mark your books, and keep them flat and open on your desk like this so the pages will turn easily.

You may now turn over to the next page and answer question 1. When you have finished answering question 1, look up so that I can tell you are done.

(When all have answered, read the question, read answer, and then give the A, B, C, or D indication.)

You are given the answer to help you learn it.

Now go ahead and answer question ____. Then look up.

(When all have answered, read the question, read the answer, and then give the A, B, C, or D indication.)

Do not change your answer. Remember it's the film that's being tested. Now go ahead and answer question ____. Then look up.

(Continue till you finish the test.)

(Alternate use of the two rationales for the unusual procedure.)

(Check to discourage "cheating" as much as possible.)

6. (Immediately after the last student has finished the last item, #40, send your projectionist to notify the school office.)

(Collect papers, pencils, and books. Turn room back to the teacher but permit no discussion of the film.)

(When the bell rings, you're done and can pack up and leave.)

APPENDIX 4

INSTRUCTIONS TO SUBJECTS RECEIVING DELAYED FEEDBACK

[Information in parentheses was for the instructor.]

Remember the film you saw yesterday on time?

We are back today to give information about the correct answers to the test.

Only those who did not get this information yesterday will receive it today.

You will be given back your answer sheet along with a test book.

The answer sheet will show which questions you missed (marked in red).

The question book will show the correct answers.

Look clear through the question book. You will find the answer to each question on the page following it. (Demonstrate)

All the answer sheets are folded. (Demonstrate)

Check particularly the answers to the questions you missed. (Question?)

(Pass out books and answer sheets together. Use the answer sheets for identifying each student who is to receive feedback today--approximately half will.)

(Watch to see that no one changes answers.)

APPENDIX 5

INSTRUCTIONS TO SUBJECTS TAKING THE RETENTION TEST

[Information in parentheses was for the instructor.]

Two weeks ago you saw a film on the subject of time. Then you took a test about it, and finally you received information about the answers to the questions. This was to help you learn the important ideas concerning time.

The first test was a test of the film. Today we are testing you to see how much of what you learned two weeks ago you can remember today.

There are 40 questions as before, and they cover the same ideas. However, they are different, so read and answer them carefully.

Those who did not see the film or the previous test should take this test anyway.

(Pass out books, pencils, and answer sheets.)

Put only your name and school on the answer sheet. (Pause)

Now read with me the instructions on the yellow sheet. (Read aloud)

Be sure to use the special pencil, fill in completely between the lines, erase completely if you need to, and don't make any other marks on either the test book or the answer sheet. Questions?

Now go right ahead with answering the questions. Remember there may be several questions on the sheets that fold out. (Show)

(Check to see that everybody gets started right away.)

(After 1/4 of the remaining time is done)

You should at least be on question 10 by now. If you are further along, you have plenty of time. Remember we're testing you this time.

Be sure and answer all the questions even if you are not sure of some.

(After 1/2 of the time is done)

You should at least be on question 20 by now. Read and answer each question carefully. We're testing how much you can remember from the film.

(After 3/4 of the time is done)

You should at least be on question 30 by now. If you are further along, you have plenty of time. This is a test of how much you can remember.

(Do further coaching as necessary.)

APPENDIX 6

POST-TEST

[Originally in booklet form]

[Pink Sheet]

INSTRUCTIONS - READ CAREFULLY

This booklet contains questions about the ideas in the film you have seen. Be sure to read each question carefully and completely before you answer.

Choose the one answer that you think is best for each question.

Put your answer on the separate answer sheet by filling in between the dotted lines under A, B, C, or D, whichever you choose as the correct answer.

Sooner or later, all of you will be given information about the correct answers. If your name happened to be pulled out of a hat, you will be given the information about correct answers today; if not, you will receive the same information tomorrow. This is simply a part of the experiment, and all of you will receive the information.

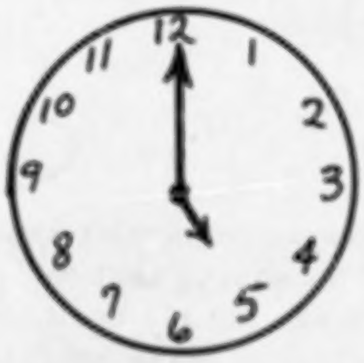
Wait for further instructions.

- -

[Buff Sheet]

SAMPLE QUESTIONS

50.



According to this clock the time is
- A. 2 o'clock.
- B. 3 o'clock.
- C. 11 o'clock.
- D. 5 o'clock.

Mark your choice in the correct place on the answer sheet.

51. The name of the day that comes after Monday and before Wednesday is

A. Thursday.
B. Tuesday.
C. Sunday.
D. There is no such day.

Mark your choice on the answer sheet. Wait for further instructions.

- -

TEST ITEMS

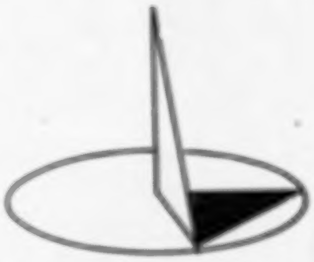
1. Time can be determined from the sun because

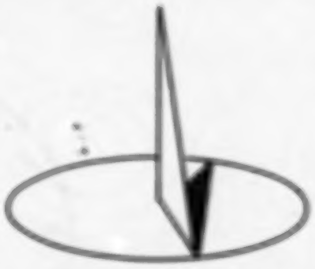
A. the sun shines hotter at different times of day.
[✓ B.] the sun is at different positions in the sky at different times of the day.
C. the sun moves back and forth like a pendulum clock.
D. both A and B are correct.

Mark your choice on the answer sheet. Then turn this page. [These instructions appeared with each item in the test booklet.]

2. Sundials to the east or west of each other, such as a sundial on the east coast and one on the west coast, tell different times because

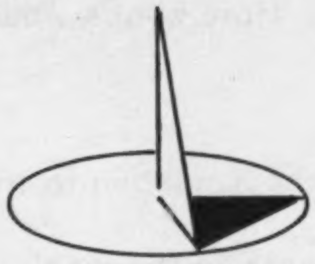
A. they are set to work at different rates.
B. they are at different sea levels.
[✓ C.] the parts of the earth they are on rotate or spin into the sun's light at different times.
D. the parts of the earth they are on revolve or move around the sun at different rates.

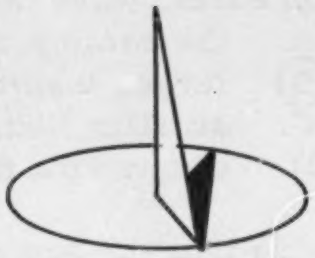




3. If the above shadows were cast at exactly the same instant, they could be explained by saying that the

A. sundials were poorly built.
B. sun was shining more brightly where the first shadow was cast and therefore the first shadow was larger.
C. shadows were cast by two different sundials many miles to the north and south of each other.
[✓ D.] shadows were cast by two different sundials many miles to the east and west of each other.





4. If the same sundial cast both these shadows, they could probably be explained by saying
   - [✓ A.] the shadows were cast at different times during a single day.
   - B. the sundial was built poorly.
   - C. the sun was shining more brightly when the first shadow was cast, and therefore the first shadow was larger.
   - D. any of the above reasons are correct.

5. To determine the part of a circle through which the earth rotates in one hour,
   - A. multiply 360 degrees by 24 hours.
   - B. add 360 degrees and 24 hours.
   - C. divide 360 degrees by one hour.
   - [✓ D.] divide 360 degrees by 24 hours.

6. If a point on the earth's surface took 36 hours to rotate through a full circle, how many hours would there be in one day?
   - A. 12 hours
   - B. 24 hours
   - [✓ C.] 36 hours
   - D. Can't tell from the information given.

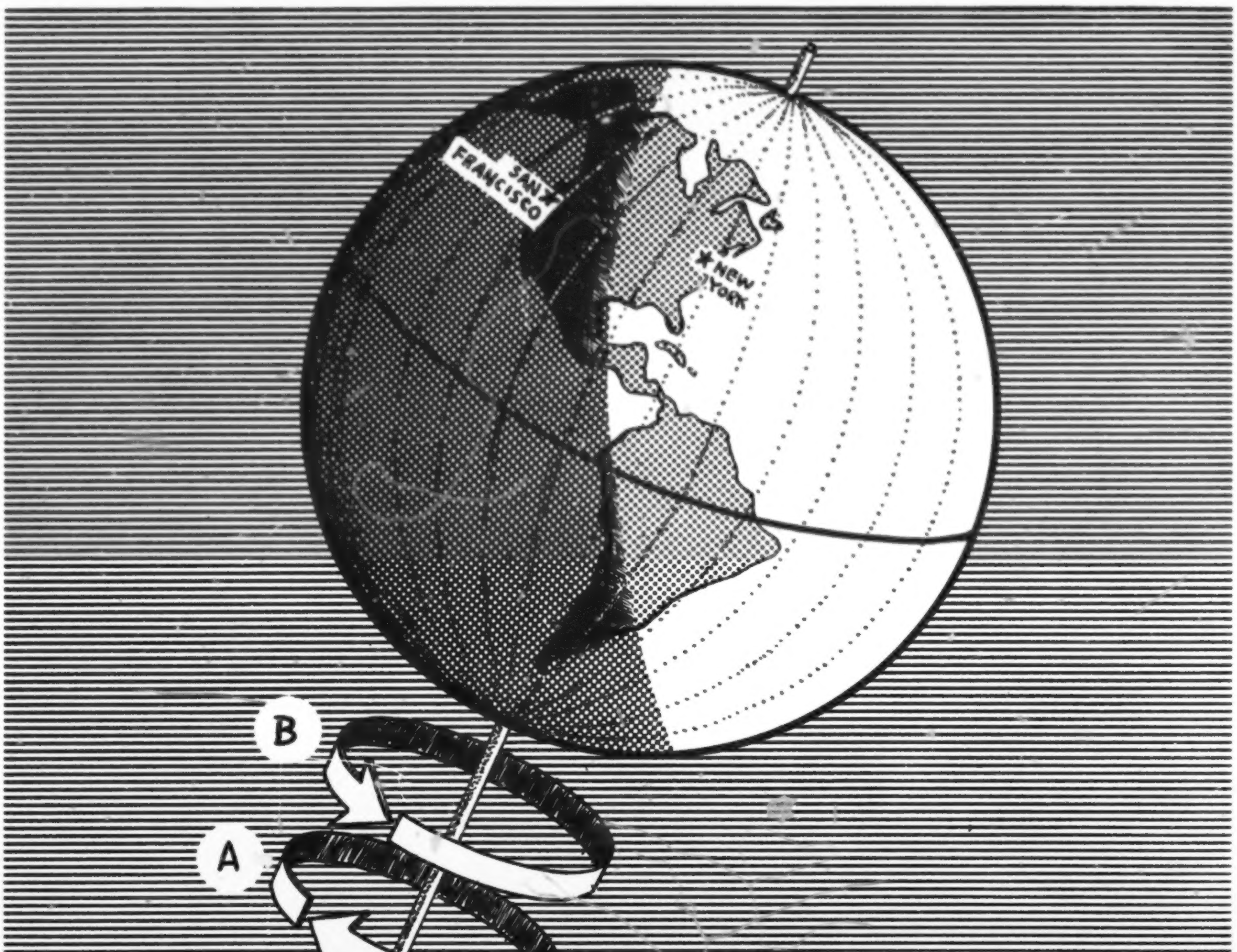
7. Standard time zones were developed because rapidly moving travelers found that
   - A. small towns all had the same time as Greenwich, England.
   - B. sun time was different in towns north and south of each other.
   - C. sun time could not be determined from a rapidly moving train.
   - [✓ D.] sun time was different in towns to the east and west of other towns.

8. Planet X, the same size as the earth, rotates through 360 degrees in 12 hours. If a standard one-hour time zone system, like the one on earth, were developed for Planet X, time zones would be

   A. the same size as the earth's.
   [✓ B.] larger than the earth's.
   C. smaller than the earth's.
   D. of any size that the people of Planet X wished to make them.

9. Knowing that the sun rises in the east and sets in the west, we can say that

   [✓ A.] the earth rotates in the direction of Arrow A.
   B. the earth rotates in the direction of Arrow B.
   C. the earth rotates in the direction of Arrow A during the day and in the direction of Arrow B during the night.
   D. we don't have enough information to make a statement about the earth's rotation.



[This picture also accompanied items 10 and 11.]

10. If the earth were to rotate in the direction of Arrow A, then the next day

- A. the sun would rise in San Francisco before it would rise in New York.
- [✓ B.] the sun would rise in New York before it would rise in San Francisco.
- C. the sun would rise in New York and San Francisco at the same time.
- D. we wouldn't have enough information to say whether the sun would rise first in New York or first in San Francisco.

11. If it is 8 a. m. in New York in the picture above, which of the following times might it be in San Francisco?

- [✓ A.] 5 a. m.
- B. 11 a. m.
- C. 10 a. m.
- D. 2 p. m.

12. Most time systems are based on 15-degree meridians counted from

- A. Washington, D. C.
- B. New York.
- [✓ C.] Greenwich, England.
- D. London, England.

13. Local time in each time zone

- A. is one to 12 hours faster than Greenwich time.
- B. is one to 12 hours slower than Greenwich time.
- [✓ C.] could be either 12 hours faster or slower than Greenwich time.
- D. could not be different from Greenwich time.

14. A traveler passing from one zone to the next one to the east must

- [✓ A.] add an hour.
- B. subtract an hour.
- C. either add or subtract an hour.
- D. not change his clock.

15. If a traveler added an hour for every zone he passed through on his eastward journey, how many hours would he have to add for a complete journey around the earth?

- A. 12 hours
- B. 36 hours
- C. It would depend on which countries he passed through.
- [✓ D.] none of the above

16. If it were not for the International Date Line, east or west bound travelers who made a complete journey around the earth would arrive back at their starting point with

A. their clock 12 hours ahead of its starting point.
B. their clock 12 hours behind its starting point.
C. their calendar the same as when they started.
[✓ D.] their calendar a day later or earlier than when they started.

17. A traveler crossing the International Date Line will, depending upon the direction he's traveling, either

A. add or subtract one hour on his clock.
[✓ B.] add or subtract a day on his calendar.
C. add or subtract 12 hours on his clock.
D. none of the above

18. If a traveler subtracts an hour for each zone as he travels west, what kind of change must he make as he crosses the International Date Line?

A. subtract 24 hours
[✓ B.] add 24 hours
C. add 12 hours
D. add the number of hours he has already subtracted

19. When we change from Standard Time to Daylight Saving Time in the spring, we should set our clock

[✓ A.] one hour ahead of our regular time.
B. two hours ahead of our regular time.
C. one hour behind the regular time.
D. two hours behind the regular time.

20. When we set the clock ahead an hour in the Daylight Saving Time system, the sun seems to

[✓ A.] rise and set an hour later.
B. rise and set an hour earlier.
C. rise an hour later and set an hour earlier.
D. rise an hour earlier and set an hour later.

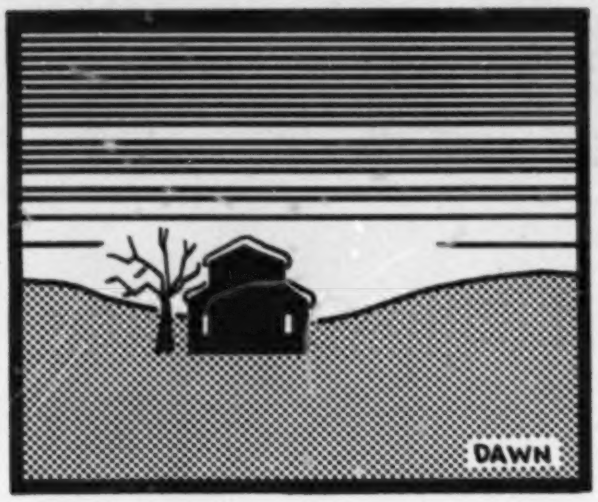
21. In the winter, by using Daylight Saving Time instead of Standard Time, we

A. gain an hour of daylight.
B. lose an hour of daylight.
[✓ C.] do not lose or gain an hour of daylight.
D. stay awake longer each day.

22. The people of Mudville, who use the Standard Time system, put on their favorite television program when their clock points to 8 p. m.

The people in the neighboring city of Watertown (in the same time zone as Mudville), who use the Daylight Saving Time system, put on the same program at exactly the same instant as the people in Mudville do. When they put on the program, their clock points to

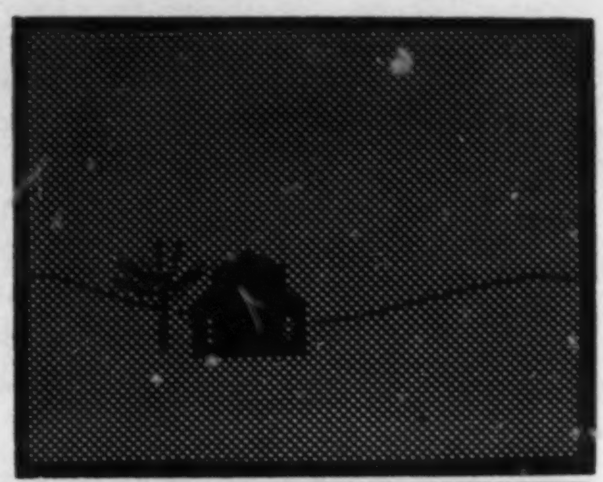
A. 6 p. m.
B. 7 p. m.
[✓ C.] 9 p. m.
D. 10 p. m.



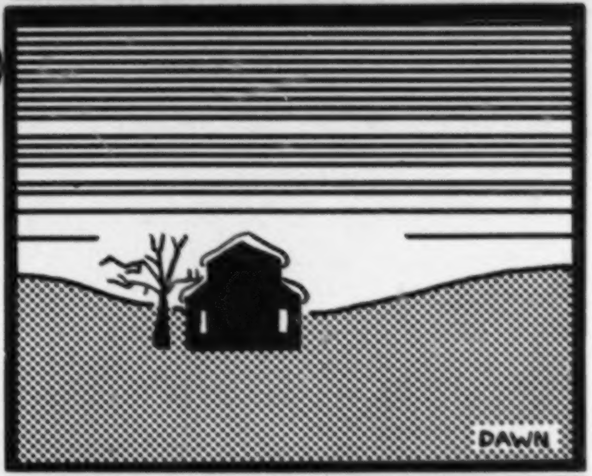
23. In winter when it is 7:30 a. m. Standard Time, it looks like the picture above.

If it were 8:30 a. m. Daylight Saving Time, which of the pictures at the right shows what it would be like?

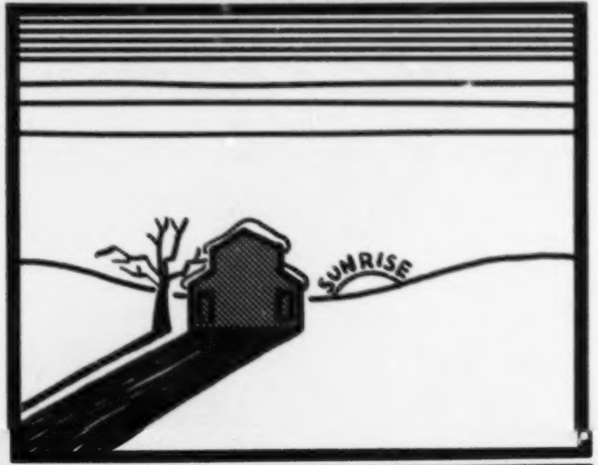
A



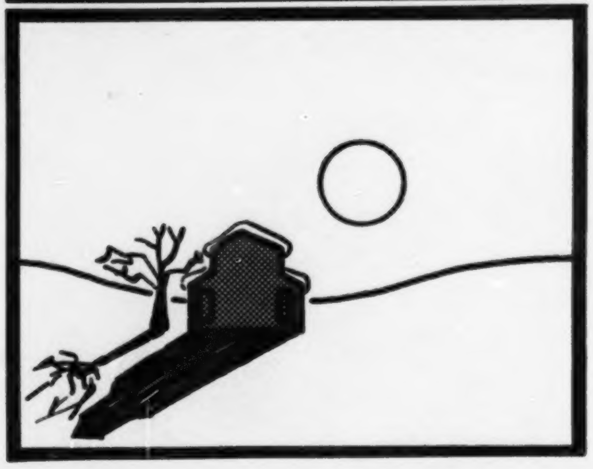
[✓ B]

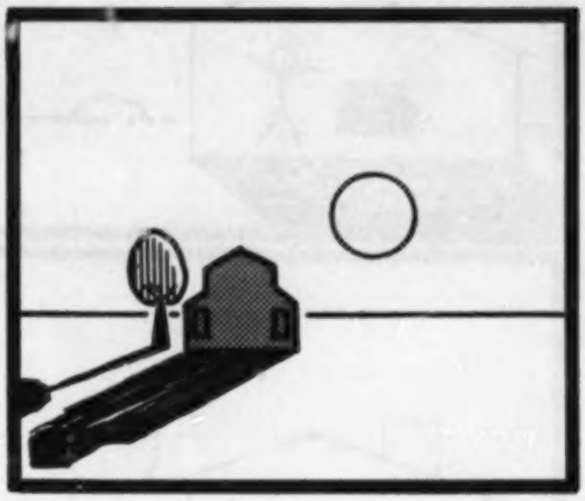


C



D

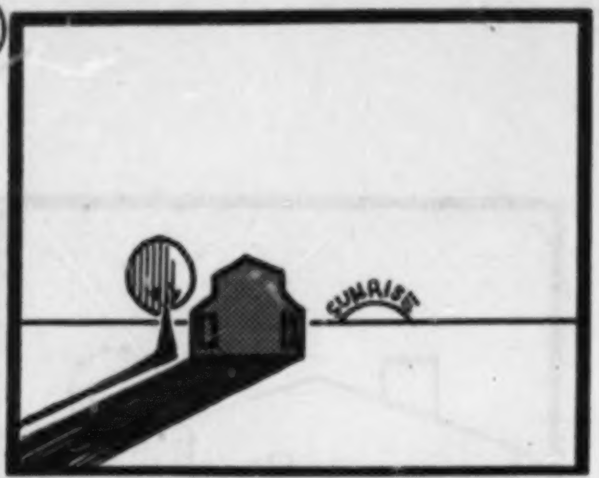




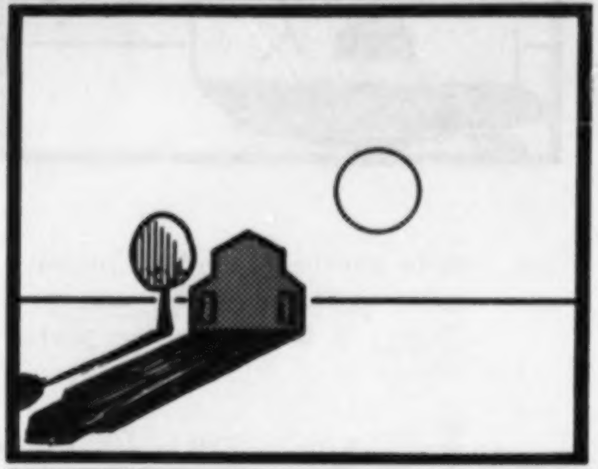
24. In summer, 7 a.m. Standard Time looks like the picture above.

If it were 7 a.m. Daylight Saving Time, which one of the pictures at the right shows what it would be like?

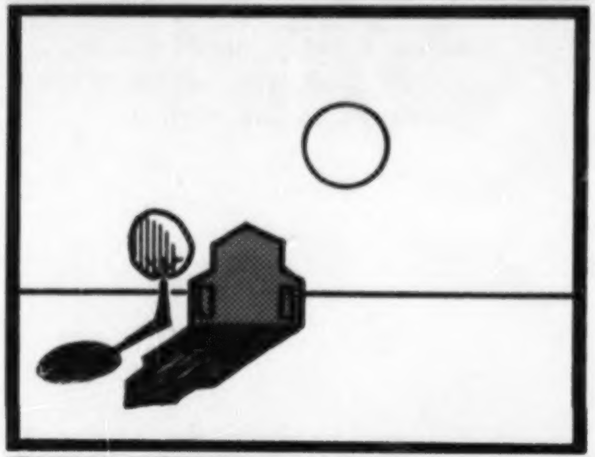
[✓ A]



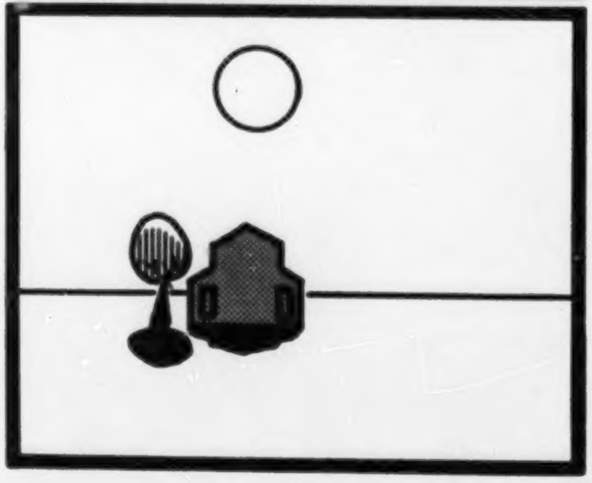
B

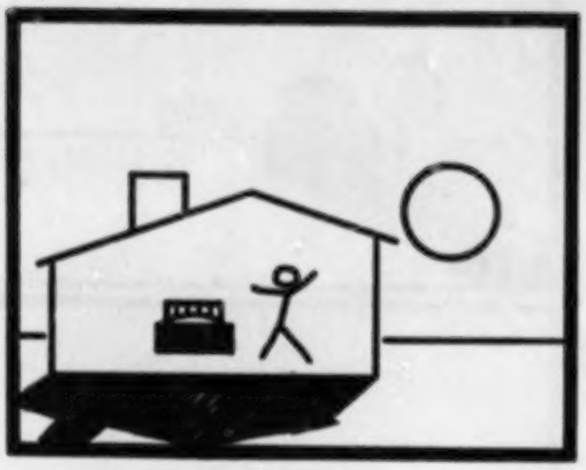


C



D

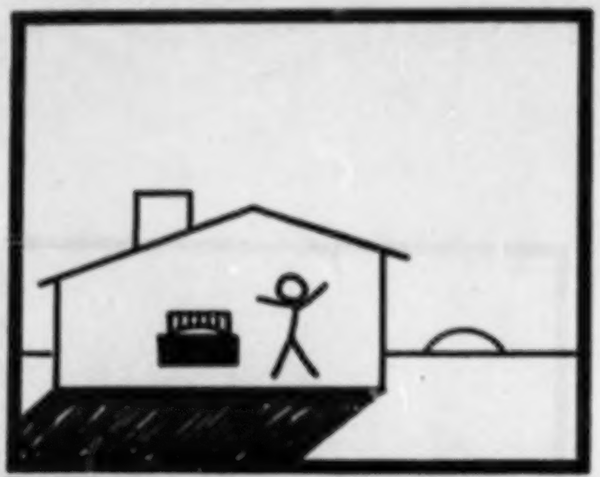




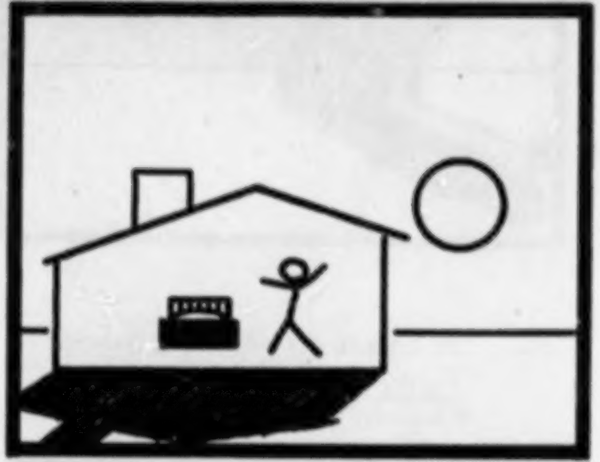
25. It is summer. When Johnny gets up at 7 a. m. Standard Time, it looks like the picture above.

If Johnny changed to Daylight Saving Time the next day and did not get up until 9 a. m., it would look like which of the pictures to the right?

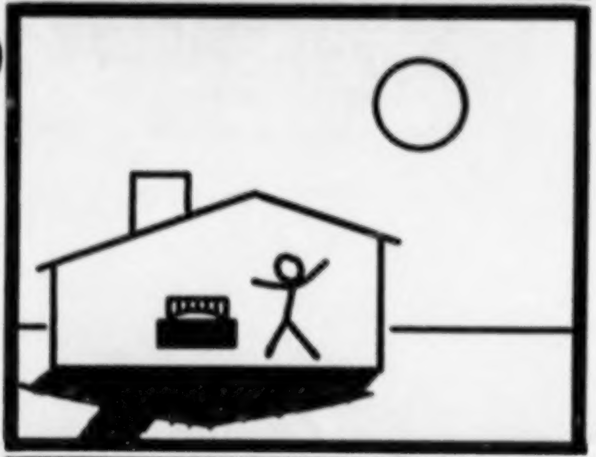
A



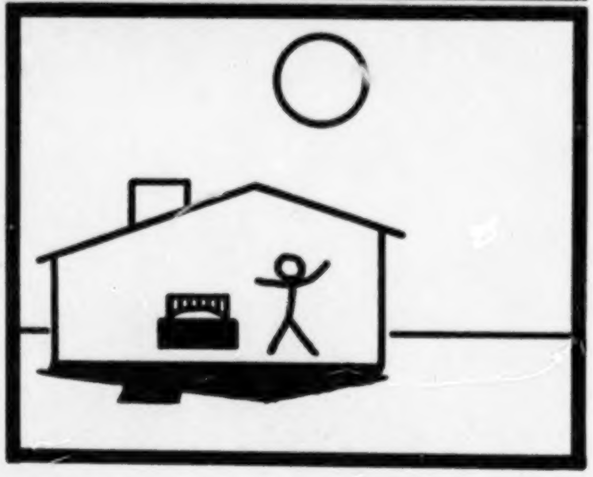
B



[✓ C]



D



26. The precise length of a day as measured by the sun's position is
    A. slightly more than 24 hours.
    B. slightly less than 24 hours.
    [✓ C.] sometimes slightly more and sometimes slightly less than 24.
    D. neither A, B, nor C.

27. In the United States the time of day is determined from observations made by
    A. Western Union.
    B. the National Bureau of Standards.
    [✓ C.] the U.S. Naval Observatory.
    D. radio stations.

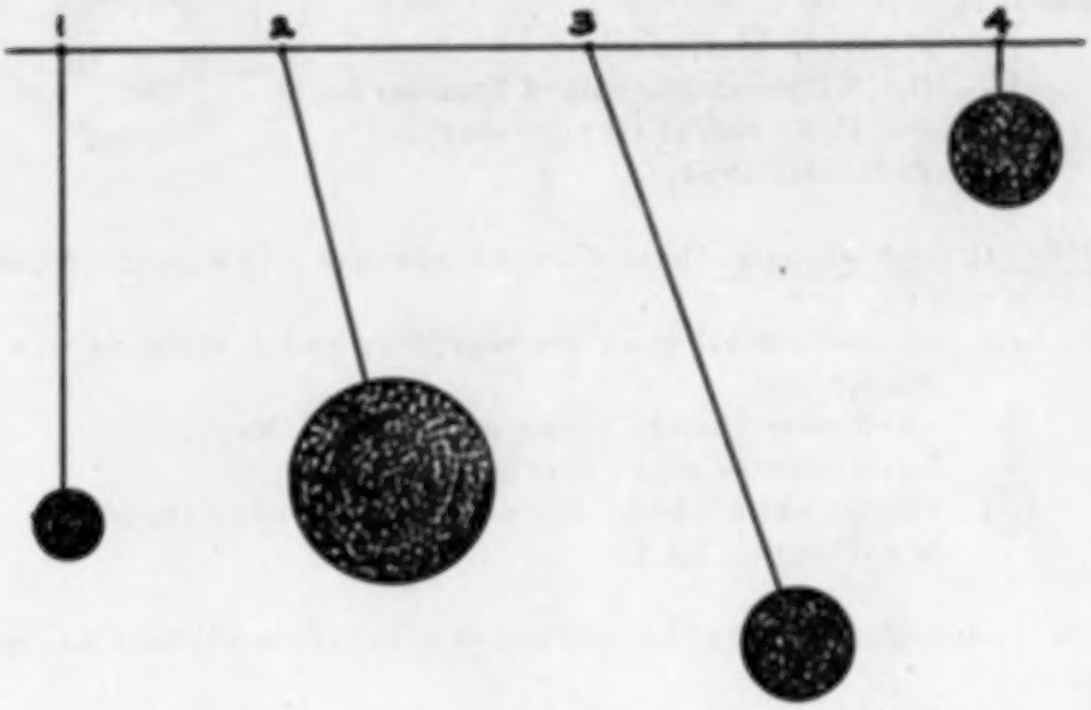
28. Official time signals, based on the special clock in the Naval Observatory, are
    A. broadcast all over the world by radio stations in every major city.
    B. used only aboard ships of the U.S. Navy.
    C. used only in this country.
    [✓ D.] broadcast all over the world by a radio station in Washington, D.C.

29. The radio stations that broadcast official time signals are operated by
    A. Time Magazine, Inc.
    [✓ B.] the National Bureau of Standards.
    C. the Columbia Broadcasting System.
    D. the Army Signal Corps.

30. Many commercial radio and television stations broadcast time signals which are
    A. generally accurate and official.
    [✓ B.] generally accurate and not official.
    C. inaccurate but official.
    D. inaccurate and not official.

31. The rate of a pendulum's swing depends on
    A. its shape.
    B. the time of day.
    C. the direction of the stars overhead.
    [✓ D.] none of the above.

32. When a very small lever escapement was developed, it became possible to make
- A. small pendulums.
- B. small clock hands.
- [✓ C.] small clocks and watches.
- D. pendulums that vibrated more rapidly.



33. Which of the pendulums pictured above would swing at most nearly the same rate?
- [✓ A.] 1 and 2
- B. 3 and 4
- C. 1, 3, and 4
- D. 1 and 3

34. Which of the pendulums above would swing back and forth at the slowest rate?
- A. 1
- B. 2
- [✓ C.] 3
- D. 4

35. The pendulum that swings back and forth at the fastest rate does so because it is the
- [✓ A.] shortest (4).
- B. longest (3).
- C. heaviest (2).
- D. lightest (1).

36. In order to determine a frequency, we divide the number of occurrences by the

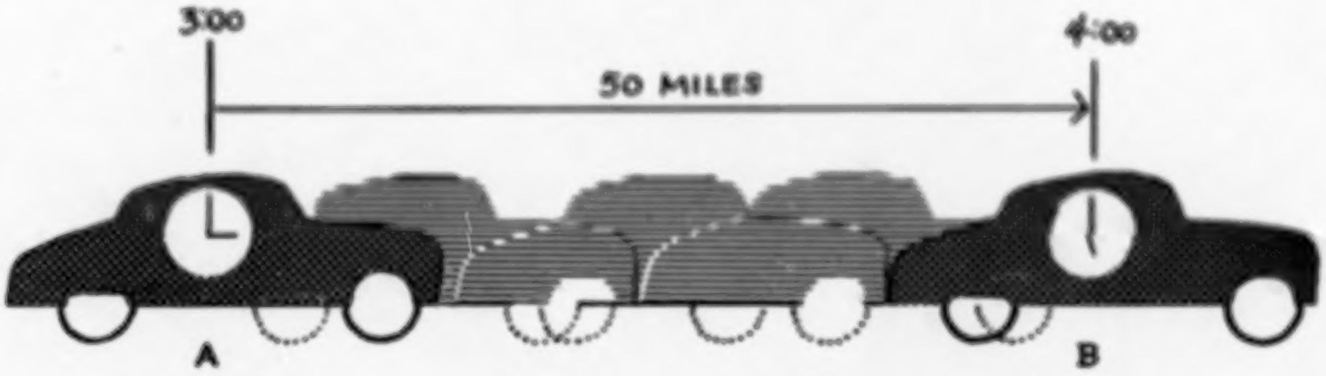
- A. number of cars or people present.
- [✓ B.] time in which the action took place.
- C. number of vibrations per minute.
- D. time it took for one occurrence to take place.

37. Time as it relates to frequency is important to electrical generators because

- A. it is measured by an electronic clock.
- B. it is measured by an electrically operated photographic device.
- C. two generators, hundreds of miles apart, must be on the same time system, such as Standard Time or Daylight Saving Time.
- [✓ D.] the 60 cycle-per-second frequency must be held constant so that two generators, hundreds of miles apart, can be used at the same time.

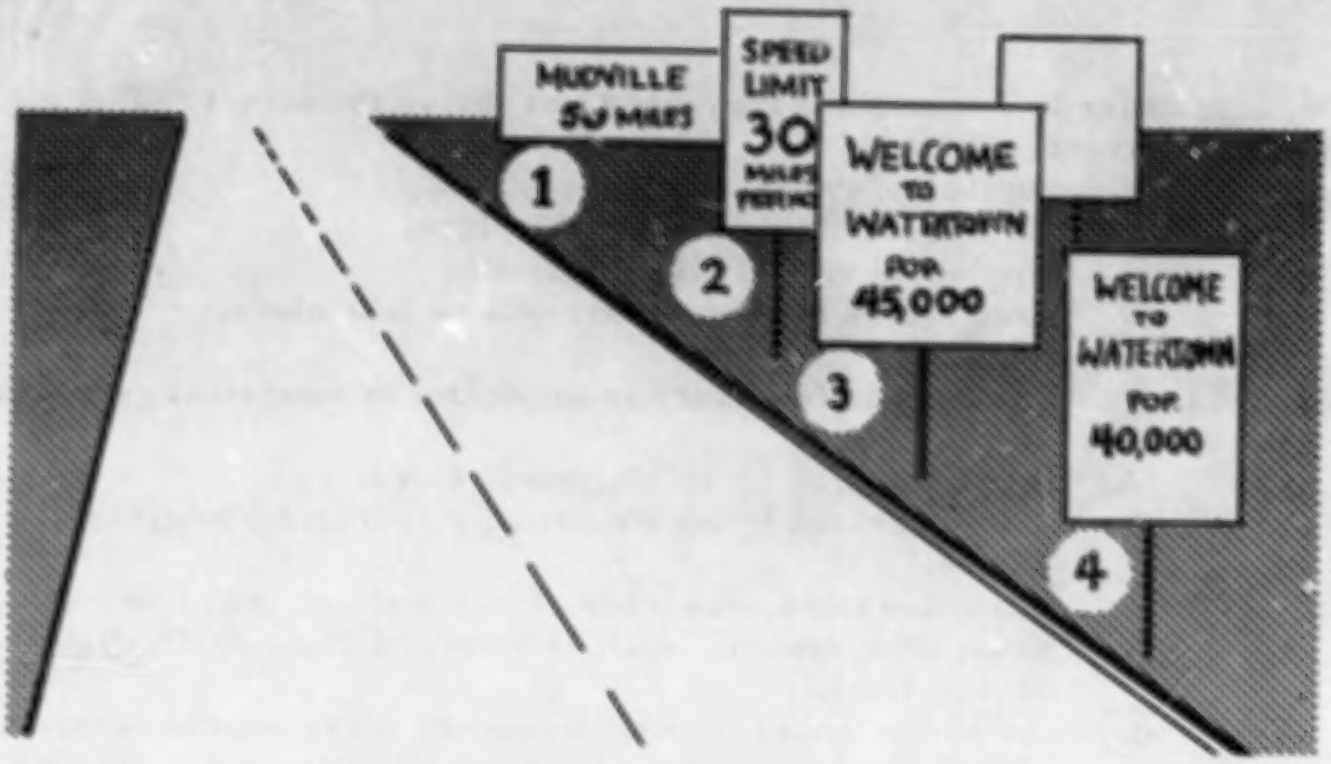
38. The careful regulation of generated current makes possible the use of

- A. the quartz crystal clock.
- [✓ B.] the ordinary household electric clock as a dependable timekeeper.
- C. the wrist watch as a dependable timekeeper.
- D. electronic escapement mechanisms.



39. There are two people in the above car. At what rate of speed has the car traveled from point A to point B?
This problem can best be solved by which of the statements below?

- A. $\text{Rate} = \frac{\text{2 people}}{\text{4 hours}}$
- B. $\text{Rate} = \frac{\text{2 people}}{\text{50 miles}}$
- C. $\text{Rate} = \frac{\text{one hour}}{\text{50 miles}}$
- [✓ D.] $\text{Rate} = \frac{\text{50 miles}}{\text{one hour}}$


MUDVILLE
50 MILES
SPEED LIMIT
30
MILES PER HOUR
WELCOME TO WATERTOWN
POP. 45,000
WELCOME TO WATERTOWN
POP. 40,000
1
2
3
4

40. **Which of the above signs illustrate(s) everyday use(s) of rate or frequency?**

[✓ A.] 1 and 3
B. 3 and 4
C. 2
D. 4

APPENDIX 7

RETENTION TEST

[Originally in booklet form]

[Buff Sheet]

INSTRUCTIONS - READ CAREFULLY

This booklet contains questions about the ideas in the film you have seen. Be sure to read each question carefully and completely before you answer.

Choose the one answer that you think is best for each question.

Put your answer on the separate answer sheet by filling in between the dotted lines under A, B, C, or D, whichever you choose as the correct answer.

Wait for further instructions.

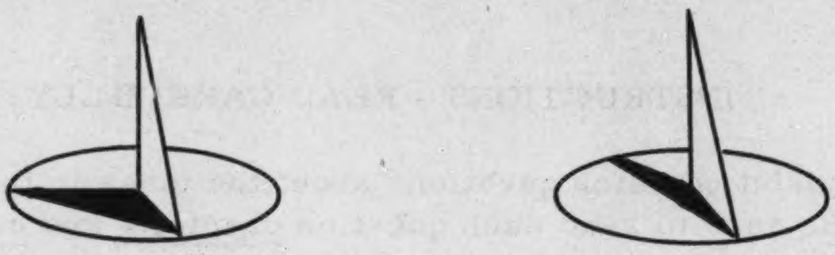
TEST ITEMS

1. Official time signals determined in the U.S. are
   - [✓ A.] broadcast all over the world by a radio station in Washington D.C.
   - B. broadcast only in the U.S.
   - C. used only aboard ships of the U.S. Navy.
   - D. used only by astronomers.

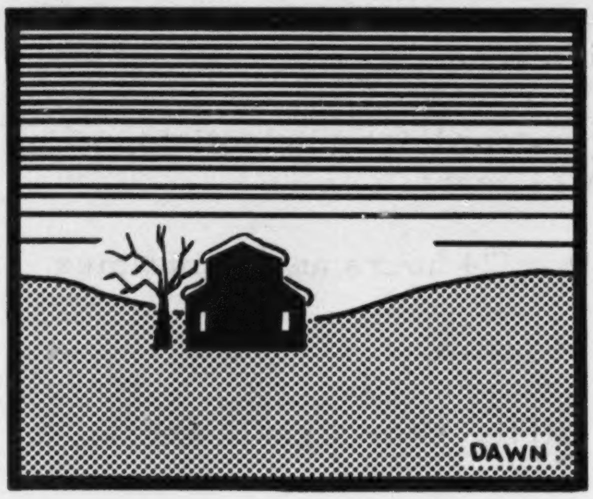
Mark your choice on the answer sheet. Then turn this page. [These instructions appeared with each item in the test booklet.]

2. Since with Daylight Saving Time the clock is set ahead an hour, the sun seems to
   - A. rise an hour later and set an hour earlier.
   - [✓ B.] rise and set an hour later.
   - C. rise an hour earlier and set an hour later.
   - D. rise and set an hour earlier.

3. Careful regulation of generated electricity makes possible the use of
    - [✓ A.] electric clocks as dependable timekeepers.
    - B. the special clock at the U.S. Naval Observatory.
    - C. smaller escapement mechanisms.
    - D. wrist watches as dependable timekeepers.



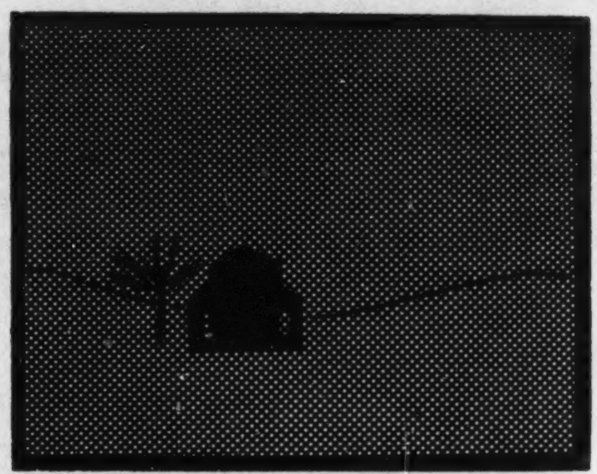
4. If these shadows were cast by the same sundial, this would mean that
    - A. one shadow was cast on a brighter day than the other.
    - B. one sundial had been moved south 15 miles.
    - [✓ C.] the shadows were cast at different times of day.
    - D. the sundial was defective.



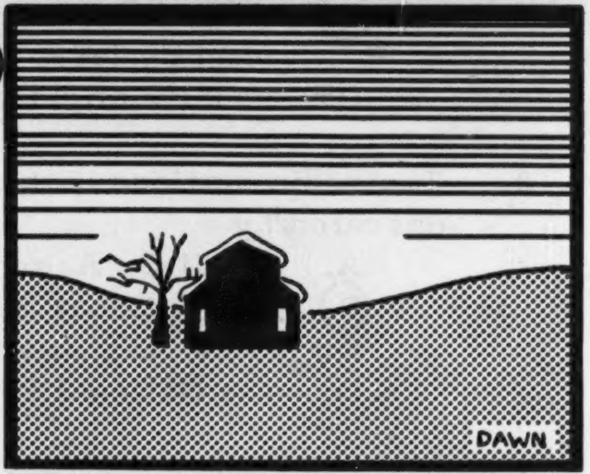
5. It is winter. When it is 8 a. m. Standard Time, it looks like the picture above.

If it were 9 a. m. Daylight Saving Time, which of the pictures at the right would show what it would be like?

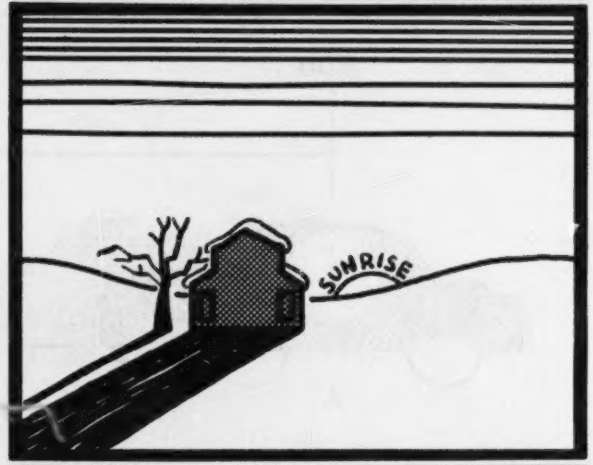
A



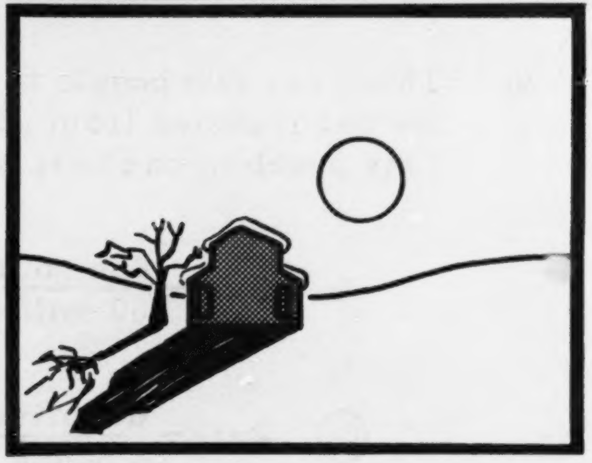
[✓ B]



C



D



6. Planet Z, the same size as the earth, rotates through 360 degrees in 36 hours. If a standard one-hour time zone system, like the one on earth, were developed for Planet Z, time zones would be

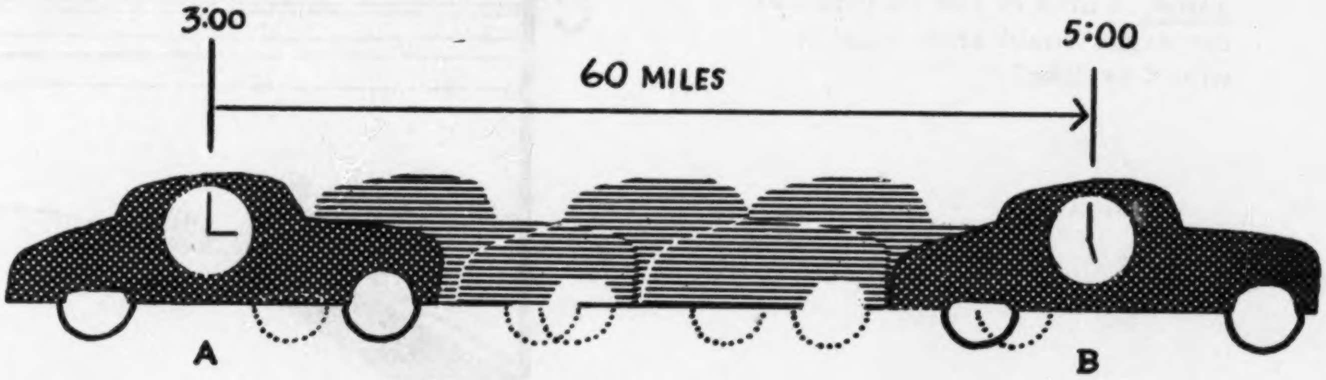
A. any size that the people on Planet Z desire.
[✓ B.] smaller than the earth's zones.
C. larger than the earth's zones.
D. the same size as the earth's zones.

7. The sun's measurement of a day is, according to scientists,

A. usually slightly more than 24 hours.
B. exactly 24 hours.
[✓ C.] sometimes slightly more than 24 hours and sometimes slightly less.
D. usually slightly less than 24 hours.

8. The radio stations that broadcast official time signals are operated by

A. the U.S. Army.
[✓ B.] the National Bureau of Standards.
C. Time Magazine, Inc.
D. the National Broadcasting Company.



9. There are two people in the above car. At what rate of speed has the car traveled from point A to point B?
This problem can best be solved by which of the statements below?

A. Rate $= \frac{\text{one hour}}{\text{60 miles}}$

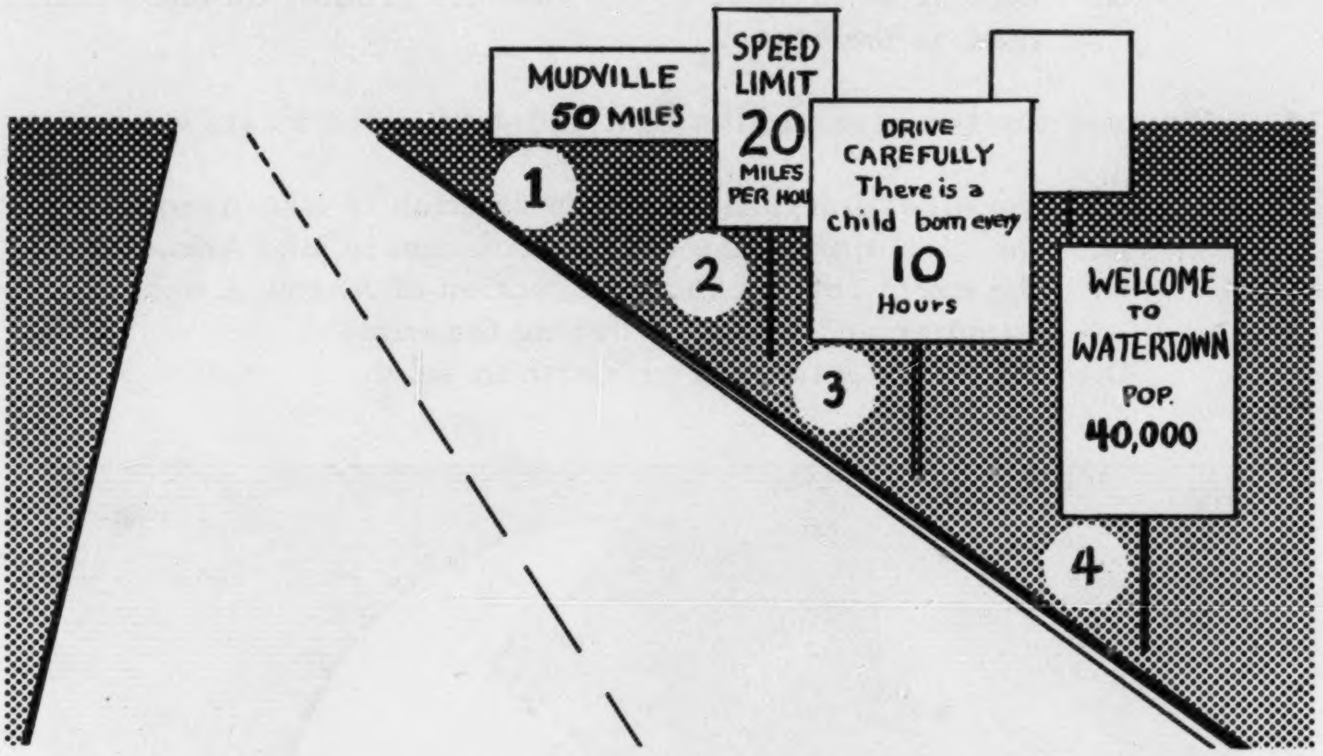
B. Rate $= \frac{\text{2 people}}{\text{60 miles}}$

[✓ C.] Rate $= \frac{\text{60 miles}}{\text{2 hours}}$

D. Rate $= \frac{\text{60 miles}}{\text{5 o'clock}}$

10. The sun can be used in the determination of time because

[✓ A.] the position of the sun in the sky is different at different times of day.
B. the movement of the sun is back and forth, like a pendulum.
C. the heat of the sun is greater at certain times of day.
D. the brightness of the sun is different at different times of day.


MUDVILLE
50 MILES
1
SPEED
LIMIT
20
MILES
PER HOU
2
DRIVE
CAREFULLY
There is a
child born every
10
Hours
3
WELCOME
TO
WATERTOWN
POP.
40,000
4

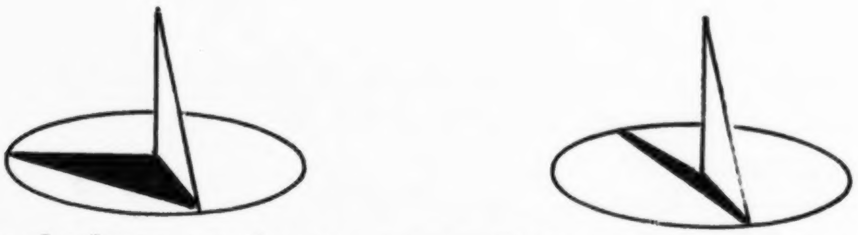
11. Which of the above signs illustrate(s) everyday use(s) of rate or frequency?

A. 2
B. 3
[✓ C.] 2 and 3
D. 1 and 2

12. The people in Sandberg, who use the Standard Time system, put on their favorite radio program when their clock points to 6 p. m.

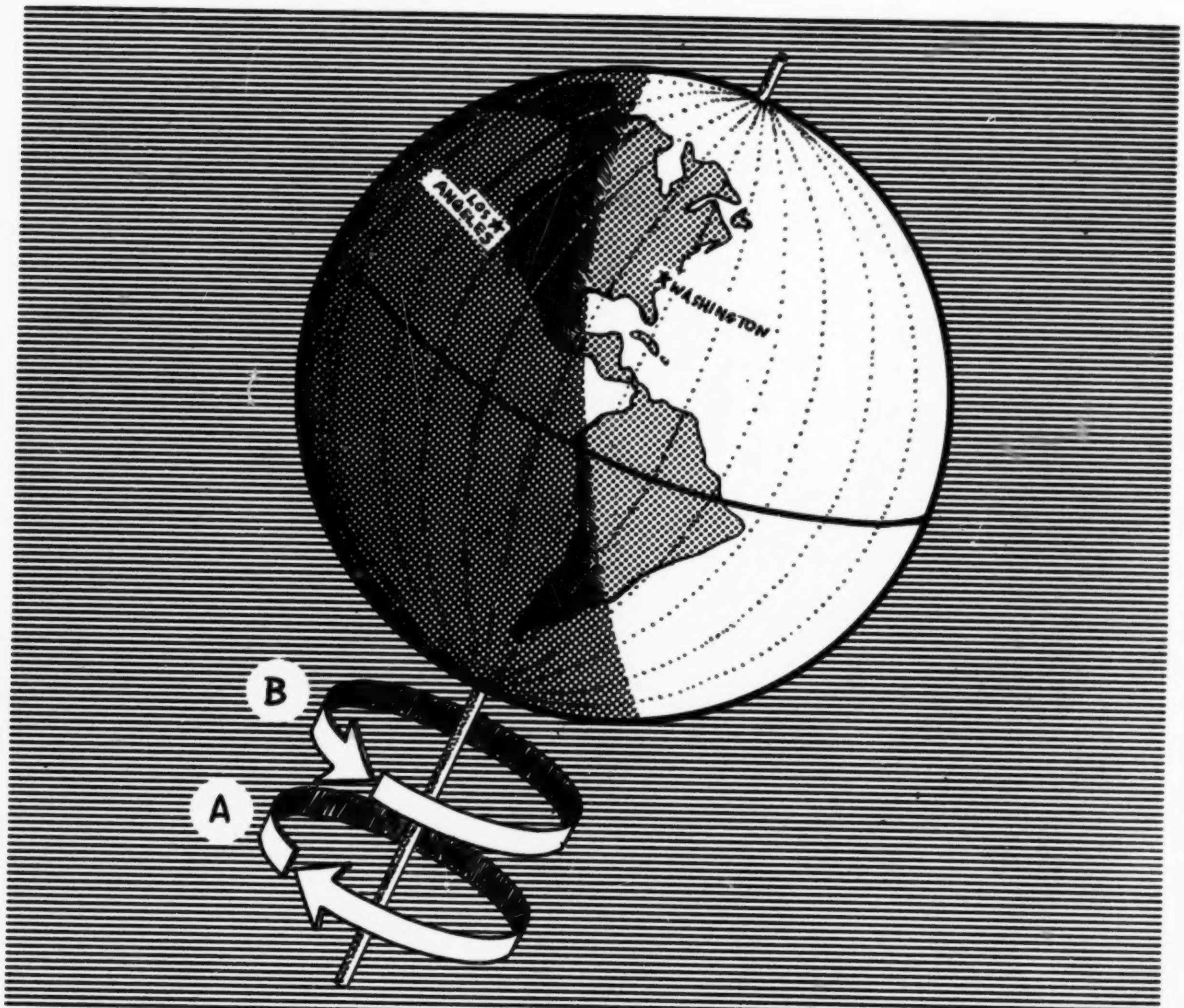
The people in the neighboring city of Waterville (in the same time zone as Sandberg), who use the Daylight Saving Time system, put on the same program at the same instant as the Sandberg people do. When they put on their program, their clock points to

A. 5 p. m.
B. 6 p. m.
C. 8 p. m.
[✓ D.] 7 p. m.



13. If the shadows on the above sundials were cast at exactly the same moment, this would mean that the
    - A. sundials were many miles to the north or south of each other.
    - B. sundials were not made the same.
    - [✓ C.] sundials were many miles to the east or west of each other.
    - D. heat or brightness of the sun was greater on one sundial than on the other.

14. Because the sun rises in the east and sets in the west, we can say that
    - [✓ A.] the direction of the earth's rotation is like Arrow B.
    - B. the direction of the earth's rotation is like Arrow A.
    - C. the earth rotates in the direction of Arrow A during summer and Arrow B during the winter.
    - D. the earth rotates from north to south.



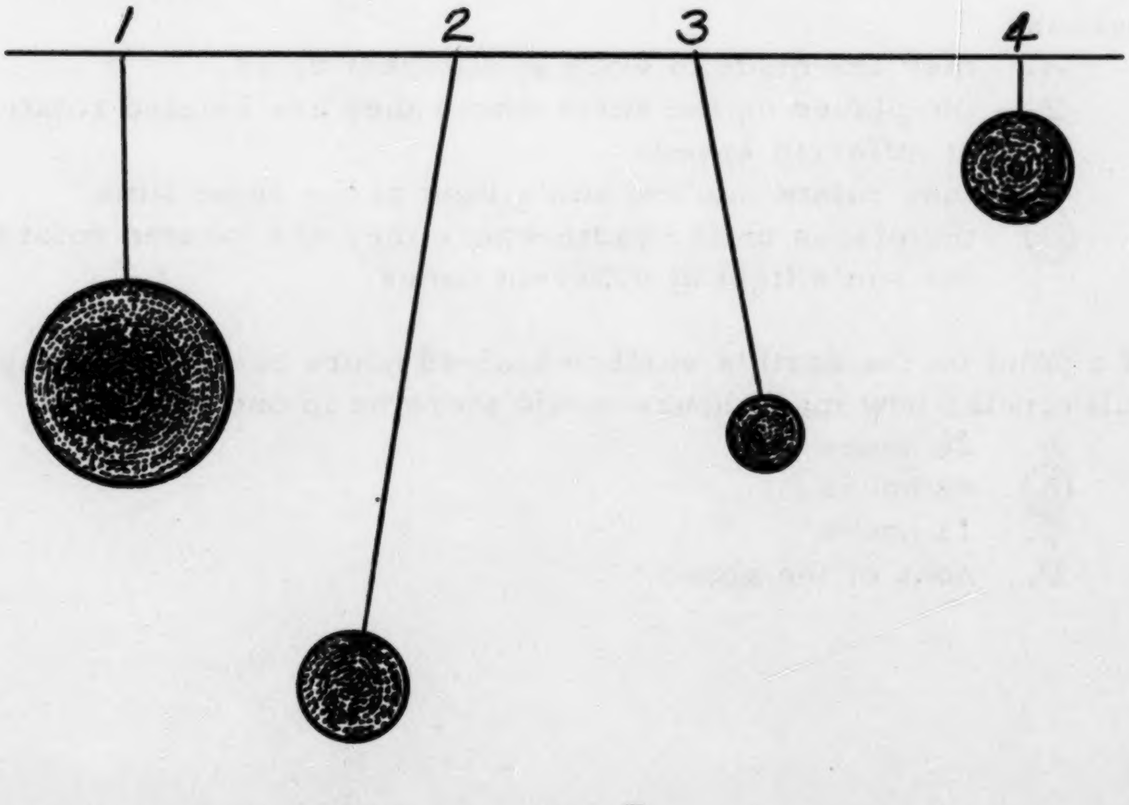
[This picture also accompanied items 15 and 16.]

15. If, for example, the earth rotates in the direction of Arrow B, the next day the sun would rise
A. at the same time in Los Angeles and Washington, D. C.
B. first in Los Angeles and then in Washington, D. C.
[✓ C.] first in Washington, D. C., and then in Los Angeles.
D. at Washington first in summer and at Los Angeles first in winter.

16. In the picture above, if it is 6 a. m. in Los Angeles, which of the following times will it be in Washington, D. C. ?
A. 3 a. m.
B. 4 p. m.
C. 8 p. m.
[✓ D.] 9 a. m.

17. If we use Daylight Saving Time in winter, we
[✓ A.] neither gain nor lose an hour of daylight.
B. gain an hour of daylight.
C. get up after the sun has been up an hour.
D. lose an hour of daylight.

18. To calculate what part of a circle the earth rotates through in one hour,
A. multiply 360 degrees by 15 degrees.
B. divide 24 hours by 1 degree.
C. multiply 24 degrees by 15 hours.
[✓ D.] divide 360 degrees by 24 hours.



[This figure accompanied items 19-21.]

19. Which of the above pendulums would swing at about the same rate?
A. 1 and 2
[✓ B.] 1 and 3
C. 2 and 3
D. 2 and 4

20. Which of the above pendulums would swing back and forth the fastest?
A. 1
B. 2
C. 3
[✓ D.] 4

21. Which of the above pendulums would swing back and forth at the slowest rate?
A. the heaviest
[✓ B.] the longest
C. the lightest
D. the shortest

22. When a traveler crosses the International Date Line, he will
A. change his clock to Greenwich Time.
B. subtract 12 hours from his clock.
[✓ C.] add or subtract one day from his calendar, depending on his direction of travel.
D. add or subtract one hour from his clock, depending on his direction of travel.

23. Sundials that are east or west of each other tell different times because
A. they are made to work at different rates.
B. the places on the earth where they are located rotate at different speeds.
C. they rotate into the sun's light at the same time.
[✓ D.] the places on the earth where they are located rotate into the sun's light at different times.

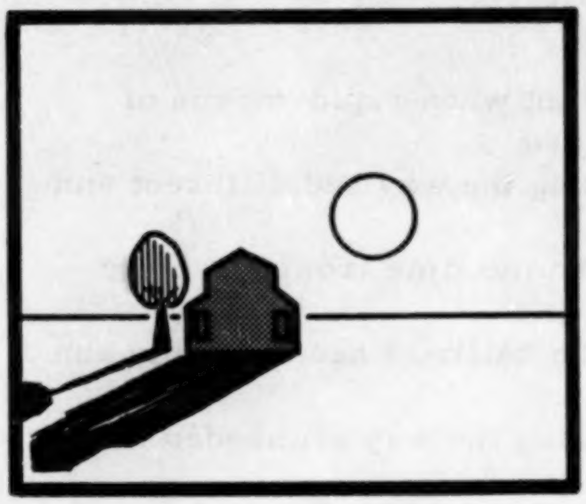
24. If a point on the earth's surface took 48 hours to rotate through a full circle, how many hours would there be in one day?
A. 24 hours
[✓ B.] 48 hours
C. 12 hours
D. none of the above

25. The rate at which a pendulum swings will depend on
A. the shape of the shadow on a sundial.
B. the position of the stars overhead.
C. the shape of the pendulum.
[✓ D.] none of the above.

26. Standard time zones became important when rapid means of transportation were developed because
[✓ A.] each of the many towns along the way had different sun times.
B. passengers could not determine time from a rapidly moving train.
C. towns north and south of the railroad had the same sun time.
D. the major trade centers along the way all needed to have the same time.

27. After the summer is over, when we change back to Standard Time from Daylight Saving Time, we adjust our clock by
[✓ A.] setting it back one hour.
B. setting it ahead one hour.
C. setting it back two hours.
D. setting it ahead two hours.

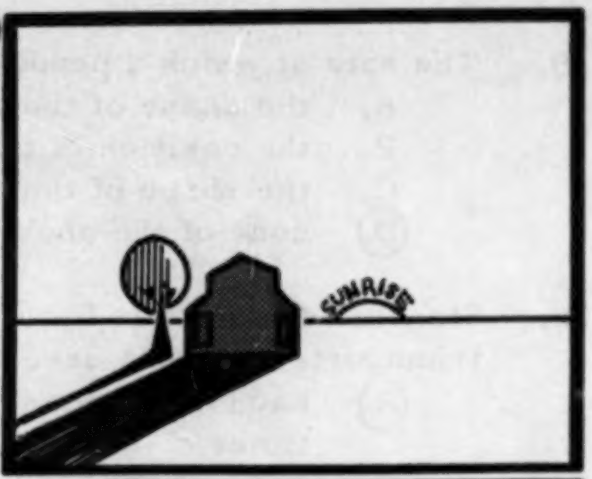
28. Time zones in most of the world are based on meridians 15 degrees apart beginning from
A. Dateville, U.S.A.
B. Washington, D.C.
C. United Nations headquarters.
[✓ D.] Greenwich, England.



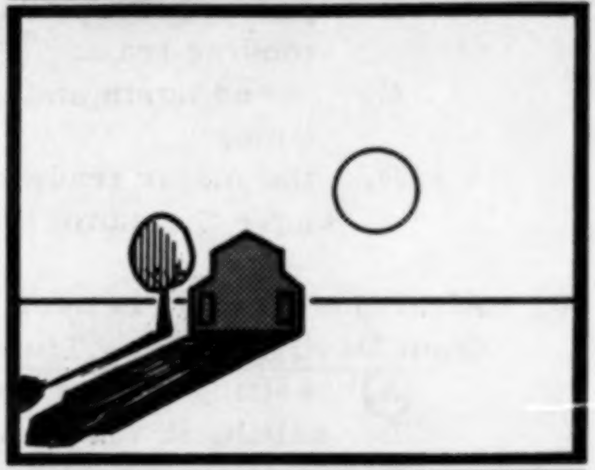
29. **In summer, 6:30 a.m. Standard Time looks like the picture above.**

If it were 6:30 a.m. Daylight Saving Time, which one of the pictures at the right shows what it would look like.

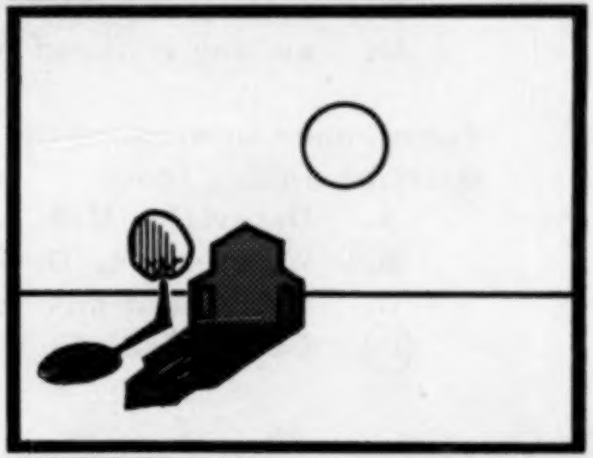
A



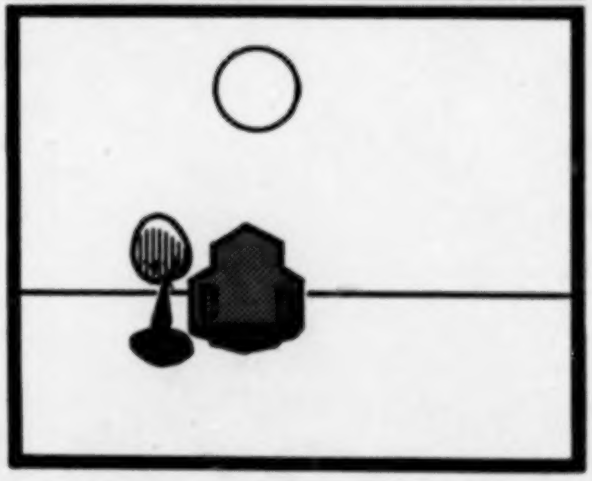
B



C



D



30. If east or west bound travelers made complete journeys around the earth without making any changes in their time keeping when they crossed the International Date Line, they would arrive back at their starting point

A. 12 hours behind the clock at the starting point.
[✓ B.] one day earlier or later than the calendar at the starting point.
C. 12 hours ahead of the clock at the starting point.
D. with the same day on their calendars as those at the starting point.

31. If a traveler adds an hour for each zone as he travels east, what kind of change must he make as he crosses the International Date Line?

A. add 24 hours.
[✓ B.] subtract 24 hours
C. subtract the number of hours he has already added
D. subtract 12 hours

32. When a very small lever escapement was made, it became possible to make

A. small clock springs.
[✓ B.] small clocks and watches.
C. pendulums that swing more rapidly.
D. small pendulums.

33. The time signals which are broadcast by commercial radio and television stations are

A. not official and not accurate.
B. official and generally accurate.
[✓ C.] not official but generally accurate.
D. official but not accurate.

34. If you were traveling west, when you left one time zone and entered the next one you would

A. add or subtract an hour as you wished.
B. add an hour.
C. leave your clock as it was.
[✓ D.] subtract an hour.

35. A constant frequency of 60 cycles per second is important in the generating of electricity because

[✓ A.] it permits the use of two generators, hundreds of miles apart, at the same time.
B. it regulates the frequency of WWV.
C. it keeps two generators on the same time system, either Standard or Daylight Saving.
D. it is measured by an electric clock.

36. The exact time of day is determined in the United States from observations made by

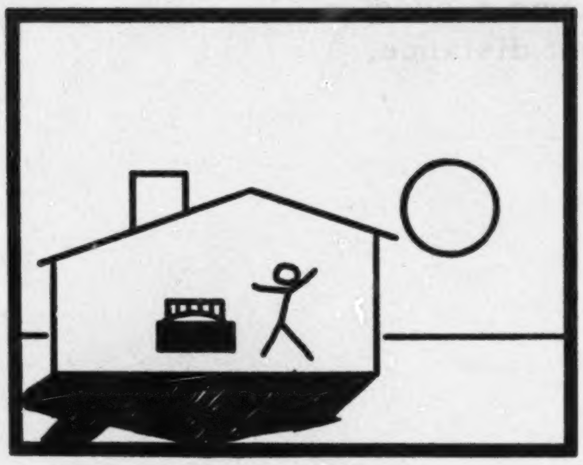
A. radio stations.
[✓ B.] the U.S. Naval Observatory.
C. Western Union.
D. the National Bureau of Standards.

37. In each time zone local time is

A. one to 12 hours faster than Bloomington time.
B. one to 24 hours faster or slower than Greenwich time.
[✓ C.] one to 12 hours faster or slower than Greenwich time.
D. none of the above.

38. If a traveler going east added an hour for each zone he passed through, how many hours would he have to add for a complete journey around the earth?

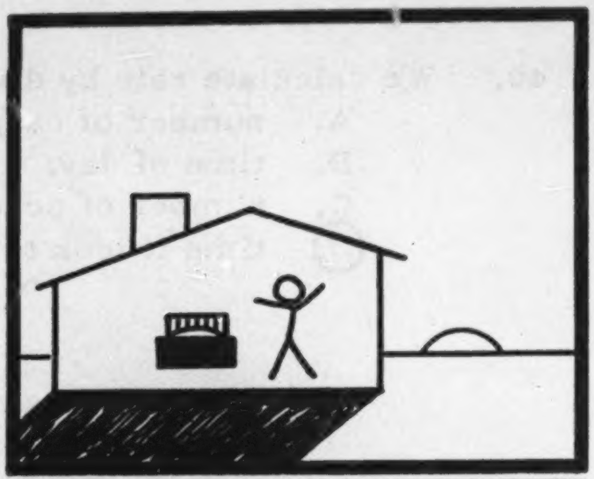
A. It would vary with the countries he passed through.
B. more than 24 hours
C. 12 hours
[✓ D.] none of the above



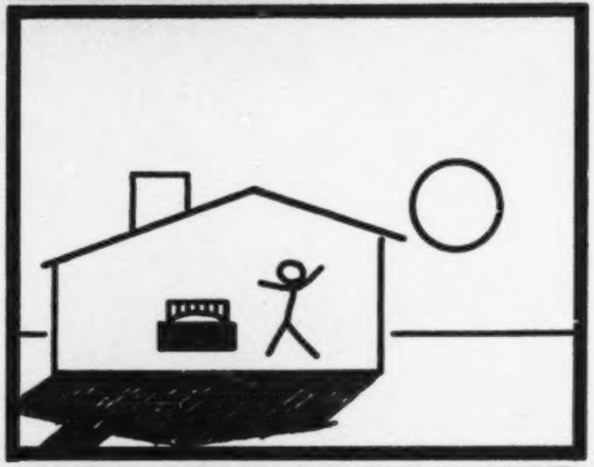
39. It is summer. When Johnny gets up at 7:30 a.m. Standard Time, it looks like the picture above.

If Johnny changed to Daylight Saving Time the next day and did not get up till 9:30 a.m., it would look like which of the pictures to the right?

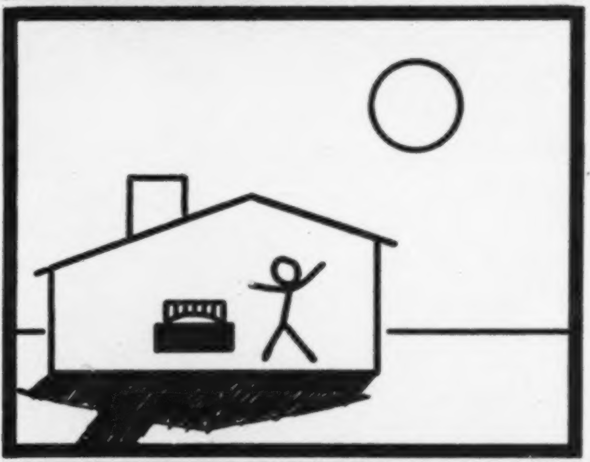
A



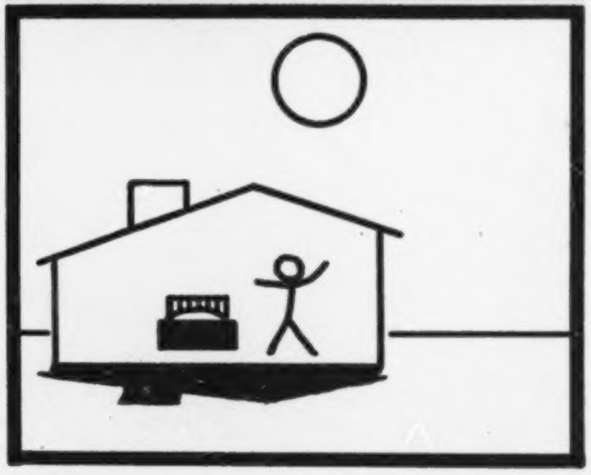
B



[✓ C]



D



40. We calculate rate by dividing the distance we travel by the

A. number of cars or children traveling.
B. time of day.
C. number of occurrences per second.
[✓ D.] time it took to travel that distance.